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Airplane Upset Training Evaluation Report

Valerie J. Gawron
Veridian Engineering, Buffalo, New York

May 2002

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Dedication

This report is dedicated to the 2359 people who died in airplane loss of control accidents worldwide between 1991 and 2000.

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Abstract

Loss of control is the leading factor in hull losses and fatalities. Loss of control accidents resulted in 2,359 fatalities 1991 through 2000 worldwide among airlines[1]. One type of loss of control is an airplane upset. Airplane upsets are defined as "an airplane in flight unintentionally exceeding the parameters normally experienced in line operations or training."[2] Airplane upsets have been addressed by the airplane manufacturers, airlines, pilot associations, flight training organizations, and government regulatory agencies who have combined forces to develop an Airplane Upset Recovery Training Aid package that includes text, simulator training, and a video. While this training package is an improvement over past practices, the motion and visual illusions that are associated with the aircraft upset are beyond the fidelity of current ground simulators. Concern must be given to negative transfer-of-training effects based on numerous simulation fidelity studies. This study was conducted to determine the benefit of this training for authorities and organizations such as the Air Line Pilots Association (ALPA), Air Transport Association (ATA), Civil Aviation Authority (CAA), Direction Generale de l'Aviation Civile (DGAC), FAA, Flight Safety Foundation (FSF), International Air Transport Association (IATA), Joint Aviation Authorities (JAA), and Luftfahrt-Bundesamt (LBA).

The study was reviewed at a workshop attended by twenty-four people representing 15 different organizations. Another 75 people were sent the 3 workshop slides and the draft evaluation plan for comment. All but two did. In all, 31 organizations (3 aircraft manufacturers, 13 airlines, 2 pilot associations, 2 air transport associations, 3 regulatory agencies, 4 pilot training companies, 3 research agencies, and the National Transportation Safety Board (NTSB)) participated. On the basis of this workshop a revised study was designed. The revised study was a between-subjects design with five groups. Each group was composed of eight, non-military pilots flying in their probationary year for airlines operating in the United States. The first group, "No aero/no upset," was made up of pilots without any airplane upset training or aerobatic flight experience. The second group, "Aero/no upset," was made up of pilots without any airplane-upset training but with aerobatic experience. Aerobatic experience was defined as at least six-hours of training completing Aileron Roll, Barrel Roll, Chandelle, Cloverleaf, Cuban Eight, Immelmann, Lazy Eight, Loop, Split S, and Stall Turn maneuvers or experience performing in airshows or stunts in an aircraft with a Federal Aviation FAA aerobatic waiver. The third group, "No aero/upset," was made up of pilots who had received airplane-upset training in both ground school and in the simulator. These pilots did not have any aerobatics training or experience. The fourth group, "Aero/upset," received the same training as Group Three but in addition had aerobatic flight experience as defined above. The fifth group, "In-flight," was made up of pilots who received in-flight airplane upset training using an instrumented in-flight simulator, the Veridian Variable Stability Learjet. This last group did not have any aerobatic experience as defined above. It was hypothesized that the more and/or more realistic the training, the better the pilot performance would be. Therefore, performance would

[1] http://www.boeing.com/news/techissues/pdf/2000_statsum.pdf

2 Airplane Upset Recovery Training Aid, 12 May 1998.

improve in the following order: No aero/no upset, No aero/upset, Aero/no upset, Aero/upset, and In-flight.

The pilots in the first four groups received a 45-minute familiarization flight in the Veridian Variable Stability Learjet immediately preceding their evaluation flight. This equalized the familiarity of these four groups with the fifth group that received in-flight airplane upset training in the Veridian Variable Stability Learjet. Pilots from all five groups completed a nominal 1.4-hour evaluation flight in which airplane upsets were introduced during performance of precision instrument control tasks. The upsets were of three types (environment, component/system, or aerodynamic) and were patterned after documented hull-loss airplane upset accidents. The objective of this program was to generate data to support industry and certification authorities for education and criteria development.

Variables that were not included in this study are total flight hours, previous flight instruction experience, and type of aircraft flown. In spite of the potentially significant effect, no effort was made to categorize evaluation pilots according to these variables due to the limited scope of the experiment.

Review of the recovery performance of the 40 evaluation pilots indicated that, for some scenarios, clearly training works – specifically, 39 evaluation pilots recovered from the windshear upset. All 40 attributed their ability to recover to training that included ground school, videos, and repetitive ground simulator practice. Review also indicated that few evaluation pilots used bank to change the direction of the lift vector to recover from nose high upsets. Further, very few used differential thrust to recover from rudder or aileron induced roll upsets (use of alternate controls). In addition and of great importance, recovery attempts from icing-induced stalls were generally inadequate and not understood.

Based on the results, the following recommendations were made by Veridian:

First, given the very large variability in flight hours and training of pilots in their probationary year and the predicted trend that this will continue, airplane upset training should account for different experience levels. . In addition, airplane upset recovery training should be given to all new hire pilots.

Second, given that a defined upset (i.e., Charlotte) was recovered by 39 of the 40 pilots, indicates that specific airplane upset training practice might prove valuable and should be provided in the ground simulator.

Practice for these scenarios should include repetition of recovery techniques until pilots perform within an empirically defined tolerance as is done with Charlotte.

Repetitive practice also plays important role in the ability to recognize the phenomena, understand the relationship of the phenomena and the aircraft state, and apply the correct response.

Third, the hypothesized beneficial effect of aerobatic training in small, maneuverable aircraft should be tested directly, given the use of this type of training is proposed at several major airlines.). This should be compared with the training effectiveness of using a low-performance, side-by-side configured aircraft for aerobatic training. If aerobatic training of either type is affective, research should be conducted to determine where in a pilot's career this training would be most effective.

Fourth, keeping AOA below stall is a critical airplane recovery technique especially in icing scenarios such as Roselawn and Detroit. Stall recovery should be expanded to include recovery from actual stalls and not only deal with approach to stall conditions. Airframe and simulator manufacturers must provide post stall data/aero packages for training post stall recoveries. In addition, AOA displays should be considered for addition to flight decks to improve crew Situational Awareness and flight safety. AOA displays are already being installed on American Airlines (Boeing 737-800, 777 on both primary flight and head up displays) and Delta Airlines (Boeing 737-800, 777, 767-400).

Fifth, the use of secondary controls such as thrust control and trim is required to aid in some airplane-upset recoveries. In Pittsburgh and Nagoya and in both icing scenarios (Roselawn and Detroit), there was a lack of ability to continue past the recognition phase and understand that different control applications were warranted.

Sixth, for nose high scenarios the most common mistake among evaluation pilots was not using bank angle to change the direction of the lift vector to recover from the pitch upset. While included in current airplane upset training curricula the inability to apply this response indicates a need for repetitive practice.

Seventh, specific criteria for the pilot-not-flying to take over due to excessive bank angle (or exceeding other flight conditions) were not observed. Airplane upset training should include procedures that address this issue considering both aircraft performance and Crew Resource Management. The procedures should also take into account aircraft flight condition and performance. Finally these criteria should be included in the training manuals for each aircraft.

Eighth, not all airplane-upset recoveries require aggressive control inputs. Some, like high-altitude airplane upsets, require just the opposite. Both types of recovery techniques, and the flight conditions during which to apply each, should be emphasized.

Ninth, additional research should be conducted:

To assess line pilot performance with experienced pilots who have been trained in airplane upset recovery.

To assess effect of learning through instructing with certified instructor pilots.

To refine the measurement and analysis of pilot performance in airplane upset recovery –since the performance of pilots who recovered versus those who did not was not always significantly different in timing and sequence since these <u>have</u> been shown to discriminate among military pilots performing similar evaluations. Amplitude measures and more extensive safety pilot evaluation should be investigated as discriminators of airplane upset recovery performance.

Airplane Upset Training Evaluation Summary

In the last decade (1991 through 2000), loss of control in flight was the largest category of commercial jet fatal accidents worldwide. Precipitating factors in these accidents have included equipment failures and system anomalies, weather phenomena, inappropriate use of flight controls or systems, inappropriate control responses by crew, or some combination of these factors. In many of these accidents flight crews could have recovered from the initial upset attitude by promptly applying appropriate control inputs. However, recovery from upset attitudes is challenging, even for highly experienced airline pilots, for the following reasons: 1) pilots rarely have opportunities to practice the appropriate procedures and 2) demanding time constraints and, in some cases, altitude constraints. Also, recovery from some upset accidents requires not only correctly manipulating the controls but also recognizing the underlying problem causing the upset. The initial upset is generally sudden and unexpected; the crew must not only quickly and correctly assess the situation but also implement recovery procedures appropriate to the situation. Usually the crew does not have enough time for the relatively slow cognitive processes of reasoning and problem solving; rather, the appropriate actions must be highly learned skilled responses that can be executed more quickly.

The NTSB has on several occasions recommended that pilots be trained to recover proficiently from abnormal regimes of flight and unusual attitudes (most notably in 1996, Safety Recommendation A-96-120). Both the FAA and the ATA encourage airlines to conduct upset attitude recovery training (see, for example, FAA Handbook Bulletin for Air Transportation 95-10, "Selected Events Training," which encourages air carriers to provide training in "excessive roll attitude...and high pitch attitude"), and many U.S. carriers now include some limited training of this sort, although the content and extent of the training varies widely. Typically, the training consists of a combination of classroom presentations and simulator training. In 1997-98 a consortium of airplane manufacturers, airlines, pilot associations, flight training organizations, and government agencies developed an airplane upset recovery training aid consisting of text, slides, and videos. The content of the training aid, including recommended recovery procedures, was based on consensus of expert opinion. The training aid included recommended procedures for excessive nose-high and nose-low attitudes.

To date, no formal study of the effectiveness of existing airplane upset recovery training programs has been made. Many questions remain unanswered, for example: How extensively must pilots practice recovery maneuvers to obtain proficiency? How often must pilots train to maintain proficiency? To what extent does generic training enable pilots to recover from a wide range of potential upset attitude scenarios? To what extent can training address the factor of surprise that occurs in actual line upsets? To what extent will training in ground-based simulators transfer appropriately to actual flight, given that ground-based simulators cannot match the forces and accelerations encountered in actual upsets and given that the fidelity of the aerodynamic models of the simulators is not well established or implemented outside of normal operating parameters? Supported by a contract from the training element of NASA's Aviation Safety Training Program, Veridian Engineering recently completed a study that bears on some of these questions.

1. The primary objective of this study was to generate data to support decision-making on the part of the FAA and the airlines. NASA's specific objectives in sponsoring the study were: To compare the relative

effectiveness of no training, aerobatic training (in light aircraft), ground simulation, combined aerobatic and ground simulation training, and in-flight simulation training on airplane upset recovery;

2. To determine how well currently trained, new-hire airline pilots are able to respond to a representative set of prototypical airplane upset scenarios;

3. To identify any specific weakness in pilots' recovery techniques and to identify areas in which current training should be improved; and

4. To determine whether some types of airplane upset scenarios are more difficult to recover from than others.

Aerobatic training in light aircraft was included because Cathay Pacific provides its pilots with this type of training and others are planning to provide it, e.g., SAS. Furthermore, in the U.S. some have suggested that aerobatic training should be required for the ATP certificate. In-flight simulation was included to assess the value of simulation with the proper forces and accelerations for pilot performance in upset recovery. This in-flight simulation was provided by a variable stability Learjet whose computer could be programmed so that the handling and performance characteristics of the Learjet resemble those of a generic swept-wing, large, twin-engine jet transport.

Methodological Issues

Caution is required in interpreting the data from this study because of inherent methodological limitations that were unavoidable. The dependent variable of greatest interest is the percentage of pilots from each training group who recovered in each upset scenario. Recovery is a dichotomous measure (i.e., pilots either recovered or failed to recover, rather than varying on a continuous dimension). Typically, studies of dichotomous measures must use relatively large samples to obtain statistically reliable results unless effects are quite large. Thus, in this study, for example, even though six out of seven in-flight pilots recovered in the Pittsburgh scenario, and only one or none of the pilots in the other four groups recovered, this difference was not statistically significant. Unfortunately cost issues limited the number of evaluation pilots planned for this study to 40. However, beyond the issue of statistical significance, the recovery data do not even hint at a consistent effect of training across scenarios.

The study also collected data on a substantial number of parameters such as time to first control input. These data are continuous and for them the study sample size is less problematic; in fact statistical power was 75 percent, which is quite acceptable. Because there is a danger of random differences appearing significant when comparing groups across many variables, the results were reported and interpreted with appropriate statistical caution in interpreting apparent differences in some of these variables.

Ideally, groups should differ only on the dimension being studied (i.e., in this study, type of previous training). However, because of practical constraints, the training groups actually differed in several other dimensions. The average number of total flight hours among groups differed greatly, ranging from 5786 for the no aero/no upset group to 2250 for the aero/upset group. (These differences were not statistically significant, which indicates that they occurred randomly rather than systematically). The groups came from

differing current airlines (the two upset groups came from a set of three major airlines; the other three groups came from a set of 27 airlines, although it is not known which pilots came from which airline because of the need for de-identification). We do not know to what extent pilots within groups differed in amount of large jet transport experience at previous airlines. For the two groups with upset training the period between training and testing may have ranged from a few days to as much as a year. In contrast, the in-flight group was trained one day before testing. Some members of the groups supposed to be without aerobatic experience actually had some, and some members of groups supposed to not have had upset training had some exposure at previous airlines, however the amount of this type of contamination appears to have been small. In addition, the differentiation between the groups with regard to the aero vs. no-aero dimension was determined simply by asking the evaluation pilot. There is no proof of how much aerobatic training any of the pilots had.

The pilots in this study were all new-hires in their probationary year and thus with limited experience in the jet they normally fly on the line. These data cannot be extended to make any inferences about how captains and first officers with more line experience might have performed in the upset scenarios. In addition, the airplane upset training the evaluation pilots in this study did receive was very brief and has been characterized as "exposure" rather than training.

For this type of study, the Veridian Learjet has the advantage of providing realistic motion cues and acceleration forces that ground simulators cannot replicate. However the Learjet has the disadvantage that the control layout is unfamiliar to the evaluation pilots, who had less than an hour of familiarization. Conceivably pilots might have performed better in an aircraft in which they had substantial experience. However, the fact that most pilots in all groups were able to recover in two scenarios suggests that unfamiliarity with the Learjet was not an overwhelming factor.

Safety trips occurred in most scenarios in which the pilot did not recover. The safety pilots determined that in most of the cases the pilot would not have been able to recover even if the safety trip mechanism had not been in place due to the lack of control inputs on the evaluation pilots' part (as reported by the safety pilot).

Although successful recovery was the primary dependent variable in this study, performance data were also collected on each of the steps appropriate for recovery in each of the scenarios, plus data on related variables. It was hoped that these data would provide a picture of what recovery actions pilots did well and what actions they failed to do well. These data might also help identify the critical differences between successful and unsuccessful recoveries. Unfortunately, in many cases the measures of performance on individual steps in the recovery procedures did not correlate well with the overall measure of recovery/non-recovery. Part of the problem may have been that the study focused on single point measures of control inputs and airplane dynamics and provided only limited information about the timing, sequencing, and magnitudes of these pilot inputs and airplane responses. To put this in historical perspective, the quest for valid automated, quantitative measures of pilot performance has been long, hard, and fraught with failure.

In addition to data on control inputs and on aircraft performance collected on the Learjet in-flight simulator, video and audio recordings were made of each flight and the safety pilot also made very brief comments after each flight. Unfortunately the safety pilot had several crucial tasks to perform during flight time and could not provide a

detailed analysis of each pilot's actions on each scenario, although that analysis would have been quite useful.

Although these various methodological issues to some extent constrain interpretation of the data from this study, they also provide valuable guidance for future studies. This study was the first attempt to examine a complex set of issues. The following section examines the implications of the data and points out questions that merit further study.

Both Veridian and NASA recognize that because of methodological limitations no one study can fully meet all of these objectives, however, we feel that the study reported here is a starting point that provides relevant data[3] that shed light on the issues --this should help policy makers and other concerned parties better understand the questions.

APPROACH

Veridian organized a workshop at the International Symposium on Aviation Psychology in May 1999 to solicit industry input to the design of this study. The workshop was attended by a wide cross-section of industry experts from aircraft manufactures, airlines, pilots' associations, the FAA, and NASA. Veridian formed a core team to advise on selection of representative accident scenarios and appropriate recovery procedures. Team members were Ben Berman (NTSB), John Cashman (Boeing), Tom Imrich (FAA), John Penny (United Airlines), Larry Rockliff (Airbus), and Warren Vanderburgh (American Airlines).

A list of recoverable airplane upset attitude accidents resulting in hull losses between 1988 and 1997 was identified and evaluated for adequacy of data regarding causes and contributing factors. From this list, eight scenarios were selected to provide a cross-section representative of the kinds of situations that have led to airplane upsets.

Appropriate recovery techniques for each accident scenario were developed, drawing upon the training procedures developed by American Airlines, United Airlines, and Delta Airlines and upon the Airplane Upset Recovery Training Guide developed by Boeing and an industry consortium. Two of the eight scenarios involved wing icing; the recovery for these two scenarios was based on advice from John Dow (FAA). The individual recovery steps for each scenario represent an idealized recovery technique that was tailored for that specific scenario. They were designed to facilitate data collection and analysis, and they are not necessarily consistent with the upset recovery procedures that have been adopted by individual air carriers. Although data were collected about the pilots' performance on all of the recovery steps, some of the steps that were enumerated for each scenario are more critical than others for affecting a recovery. Results for pilot performance of these most critical recovery steps are presented and discussed in this summary.

ACCIDENT SCENARIOS AND RECOVERY TECHNIQUES

Charlotte, 2 July 1994

A DC-9 on an ILS approach encountered a microburst with associated windshear

[3] The Veridian study generated a massive amount of data. An industry workshop is scheduled for 8 January 2002 to discuss the implications of these findings for airline training. The current draft of Veridian's report, together with this executive summary, is being sent to workshop participants to provide a basis for discussion. Feedback from the workshop discussions will be incorporated into final versions of these documents.

and high sink rate.

Birmingham, 10 July 1991

A Beech C99 on final approach encountered a thunderstorm cell with strong vertical air shafts and associated turbulence and entered a nose high attitude with 45 degree left bank.

Toledo, 15 February 1992

The captain flying a DC-8 on a second missed approach became spatially disoriented, apparently from a combination of physiological factors and a possible failed attitude indicator, and allowed the airplane to enter a nose low steep bank. The first officer took control but was not able to recover.

Shemya, 6 April 1993

The leading edge wing slats of an MD-11 inadvertently deployed in cruise flight, leading to reduced pitch stability combined with light control forces and resulting in violent, pilot-induced, pitch oscillations.

Nagoya, 26 April 1994

The pilot manually flying an Airbus 300 on approach inadvertently triggered the GO lever, which changed the flight director to Go Around mode and caused a thrust increase. The autopilots were subsequently engaged, while the pilot continued pushing against the control wheel. The horizontal stabilizer automatically trimmed to the full nose-up position, and the aircraft stalled.

Pittsburgh, 8 September 1994

During initial approach a B737 experienced yaw/roll, due to uncommanded movement of the rudder to its blowdown limit, apparently in the opposite direction commanded by the pilots.

Roselawn, 31 October 1994

During descent to 8000 feet in icing conditions an ATR 72 experienced uncommanded roll and rapid descent due to sudden aileron hinge movement reversal caused by a ridge of ice accreted behind the de-ice boots.

Detroit, 9 January 1997

An EMB-120RT experienced uncommanded roll and rapid descent caused by a thin, rough accretion of ice on the lifting surfaces.

METHOD

Five groups of new-hire airline pilots who had received different types of training relevant to aircraft upset recovery were tested in Veridian's variable stability Learjet in-flight simulator in situations that recreated the conditions of the eight accident scenarios to the extent practical. The Learjet was used rather than conventional ground simulators to provide the total motion and acceleration forces together with the real flight experience that ground simulators cannot duplicate.

The right-seat pilot station of the Learjet has wheel, column, and rudder controls programmed to replicate the force and displacement characteristics of a generic airline-type aircraft in pitch and roll. The Learjet's response to control inputs replicates the

actual forces, motions, and accelerations pilots would experience in a large transport aircraft. The right seat instrument panel has an electronic visual display with ADI and airspeed and altitude vertical readouts. Other controls (e.g., flaps) and displays (e.g., engine monitors) are standard Learjet equipment.

The Learjet has side-by-side pilot stations. The evaluation pilot (i.e., the subject in the experiment) sits in the right seat and the safety pilot in the left seat. The safety pilot taxis and controls the aircraft until after takeoff, sets up the configuration to be simulated, monitors the aircraft and evaluation pilot state, assumes control of the aircraft if necessary, and performs final approach, landing, and taxi-back. A flight engineer sits aft of the right pilot station and controls simulation and data collection. The evaluation pilots flew using a standard vision restriction device to simulate IFR flight.

The Learjet has a safety system that returns configuration to normal Learjet operating and handling characteristics, either when the safety pilot presses a switch or automatically when the aircraft exceeds preset values for various parameters. Safety trips of particular relevance to this study are acceleration limits (+2.8g max; 0.15g min) and angle of attack limits (+10 degrees max; -5 degrees min).

Each group was composed of eight airline pilots in their probationary year who had no military flight experience. The groups were:

No aero/no upset: These pilots had no more than six hours of formal aerobatics training and had not received a formal course in upset attitude recovery training.

Aero/no upset: These pilots had not received a formal course in upset attitude training but did have at least six hours of aerobatics training or had an FAA aerobatic waiver.

No aero/upset: These pilots had no more than six hours of formal aerobatics training but had received a formal course in upset training at their current airlines (either American Airlines AAMP, Delta Airlines CAST, or United Airlines AMP).

Aero/upset: These pilots had both formal aerobatics training and a formal course in upset training.

In-flight: These pilots had no more than six hours of formal aerobatics training and no formal course in upset training; instead they received upset recovery training in Veridian's Learjet in-flight simulator.

The first four groups received a 45-minute familiarization flight in the Learjet to reduce differences from the In-flight group in familiarity with the Learjet. The familiarization flight included turns up to 45 degrees of bank, accelerations and decelerations, and changes in configuration but did not include upset attitudes.

Substantial differences in experience occurred within and between the groups of pilots. Total flight hours ranged from about 1000 to around 12,000. The average of flight hours ranged from 2250 for the aero/upset group to 5786 for the no aero/no upset group. The two groups with upset training came from only three airlines, whereas the other three groups came from one of those three airlines plus 15 other airlines. Pilots also presumably varied in the number and type of companies for which they had flown before joining their current airline.

The following types of data were obtained:

1. The computer recorded data about the position, motion, and attitude of the aircraft, the position of controls, and the occurrence of safety trips;

2. After the flight, measures of time to first control inputs, number of first correct control inputs, number of correct actions, time to recover, number of safety trips, and altitude loss were calculated;
3. For each recovery attempt, whether the evaluation pilot recovered successfully was recorded;
4. For each safety trip, the possibility that a safety trip might have prevented recovery was evaluated in flight by the safety pilots; video and audio records of the evaluation pilots' recovery actions;
5. After the flight the Veridian safety pilot rated the evaluation pilot's overall performance on four dimensions, using a 5-point scale;
6. The flight test engineer recorded brief comments about each pilot's performance during each scenario;
7. A questionnaire with which evaluation pilots provided information about flight experience and training, rated forms of training, and were given an opportunity to make comments; and,
8. A post-flight debriefing in which evaluation pilots could provide comments on each scenario. Correct procedures for each scenario were presented to the evaluation pilot after the completion of all data collection and interactive discussions were held so that this evaluation would also be a positive learning experience.

The assessment of successful recovery was performed as follows: Immediately following each recovery attempt, safety pilots assessed the evaluation pilot's success or failure in returning the airplane safely to straight and level flight. Operationally, a successful recovery meant that the VSS did not safety-trip, or if it did, the safety pilot judged that the evaluation pilot's control inputs would have been successful. Conversely, safety pilots classified failed recoveries as those in which the VSS safety-tripped without the evaluation pilot having initiated correct, positive actions, or those in which the safety pilot, noting the absence of a proper response by the evaluation pilot, took control prior to a safety trip. Note that the recovery data were independent of the data on evaluation pilots' adherence to the individual steps of the recovery procedures developed and agreed upon by the consortium as described above. Further, there are no data on the accuracy of these procedures or on how closely pilots must adhere to them (what tolerances there are) to recover an aircraft to straight and level flight. Nor was the amplitude of pilot inputs collected, reduced, or analyzed. This study is the first to test the procedures and to measure the adherence of pilots to these procedures.

RESULTS

Performance differed markedly by scenario. Recovery ranged from 97% of pilots in the Charlotte scenario to 11% in the Shemya and Birmingham scenarios.

Charlotte

This maneuver was presented to the participating pilots as a windshear event on short final. The cause of the simulated accident was an encounter with a microburst on approach. The key to recovery was to obtain maximum thrust, and to maintain an angle of attack near stick shaker.

Results. Ninety-seven percent of the evaluation pilots were able to recover from this scenario. The one pilot who did not complete a successful recovery was impeded by a safety trip. There were no reliable differences between training groups neither with

respect to recovery nor with respect to any individual recovery elements. It is interesting to note that none of the pilots disengaged the autopilot and that almost half of the pilots changed gear and/or flap setting during recovery.

Discussion. All the pilots who participated in the study indicated that they have had substantial training in windshear recovery. Thus, these results demonstrate the effectiveness of training for such "textbook" situations.

Most pilots did not press the autopilot disengagement button, even though such an action is emphasized during training on most aircraft types as an habitual action to be taken early in any upset recovery. However, the autopilot was not engaged entering this scenario, and the evaluation pilots may have remained aware of their automation status as they began recovery. The fact that some pilots changed flap or landing gear configuration shows that there may be (depending on aircraft type) wide margins of tolerance within which it is still possible to affect a successful recovery.

Birmingham

This maneuver was presented to participating pilots as an approach in the vicinity of thunderstorms with reports of moderate to severe turbulence. The underlying cause of the upset simulated was severe turbulence leading to an airplane upset (45 degree bank with nose-high attitude). Importantly, the upset was not in the core of a microburst and did not require standard windshear/microburst recovery techniques. In fact, in this scenario, holding pitch rather than lowering the nose resulted in stalling the airplane. The initial conditions were a clean configuration at 180 knots. The aircraft was then upset with an uncommanded left roll and pitch up, and light turbulence was simulated. The nose-up pitching moment in this scenario was strong enough that holding full nose-down elevator input was inadequate to control the pitch rate without being supplemented by applying nose-down pitch trim or rolling the airplane to divert the lift vector from the vertical.

Results. Eleven percent of the evaluation pilots were able to recover from this scenario. There were no reliable differences between training groups with respect to recovery, nor with respect to any individual recovery elements.

Evaluation pilots who recovered differed from those who did not only in fewer encounters with safety trips due to lack of timely inputs (as reported by the safety pilots who were observing them). There were no significant differences along any of the measures of flight control inputs or other control responses.

On average, evaluation pilots responded by quickly applying aileron and rudder to correct the initial roll, but failing to apply nose-down elevator in a timely manner, resulting in loss of airspeed to aerodynamic stall.

Discussion. As a group, pilots appeared to respond consistently with their training to fly the airplane first for excessive bank and for microburst or windshear recovery, rather than for high nose-up attitude. Notice that the latter two are in conflict and the introduction, as a thunderstorm scenario appeared to prime the pilots for windshear recovery. Recovery from a high nose-up attitude requires applying nose forward pitch to unload the aircraft and using bank angle to help reduce pitch attitude. Windshear/microburst recovery emphasizes maintaining pitch near stick-shaker so as to extract as much lift as possible from a low-energy state and maintenance of wings-level roll attitude.

This scenario stands in stark contrast to the Charlotte accident. Also introduced as an approach in the vicinity of thunderstorms, that scenario introduced a roll and high

sink rate, and all but one pilot recovered. These two scenarios require opposite pitch commands for recovery, with a very similar chain of precipitating events. Evaluation pilots appeared to diagnose the Charlotte scenario correctly and the Birmingham scenario incorrectly. The former is consistent with windshear/microburst training that is now routinely trained throughout the industry. The latter is consistent with airplane upset recovery training, which is as yet trained less comprehensively. Primed with a thunderstorm scenario introduction, evaluation pilots appeared to initiate windshear/microburst recovery procedures. As a result, they did not implement corrective actions uniquely required for this accident scenario.

Toledo

Investigators concluded that the captain of this flight became disoriented and rolled the airplane into an upset. The first officer assumed control of the airplane and attempted recovery, but his roll and pitch control inputs were begun too late and were of inadequate magnitude. Investigators stated that the airplane could have been recovered if, after rolling the airplane nearly level, the first officer had applied sufficient pitch-up (elevator) input to obtain the airplane's maximum vertical g load limit.

In this scenario, evaluation pilots played the role of the accident first officer, taking over from the safety pilot as the airplane rolled from a normal level-off and left turn into a steeply banked, nose-low upset. The keys to recovery were to recognize the captain's incapacitation and assume control of the airplane, roll the airplane aggressively toward wings level, retard thrust to avoid exceeding corner speed, and (only after the wings were nearly level) apply column back pressure to obtain the airplane's maximum vertical g load.

Results. Eighty-six percent of the evaluation pilots were able to recover from this scenario. Compared to evaluation pilots who did not recover, those who recovered successfully from this scenario were more likely to reduce thrust to avoid excessive airspeed, make the correct nose-up elevator input quickly, and impose less vertical g loading during the recovery attempt.

Pilots who recovered obtained significantly better performance on two measures of the outcome of the recovery attempt: they exceeded the 210-knot corner speed by fewer knots (35 knots, compared to 107 knots for the non-recovery group) and lost less altitude (996 feet compared to 2,697 feet for the non-recovery group).

There were no reliable differences between training groups with respect to recovery, nor with respect to any individual recovery elements.

Discussion. Once the transfer of control to the evaluation pilot was complete, this was a straightforward recovery from a nose-low, increasing airspeed, and steep-banked condition. This condition is addressed in all upset training curricula, including the FAA instrument-rating curriculum to which all evaluation pilots would have been exposed. The large percentage of evaluation pilots who recovered successfully is consistent with their prior exposure to and experience with this kind of upset. Regarding the execution of the key recovery steps, most pilots in both the recovery and non-recovery groups managed the roll inputs well; however, the failure of any of the pilots in the non-recovery group to retard the throttles as airspeed exceeded the corner value highlights the importance of this step in the nose-low upset recovery procedure. The smaller values for airspeed gain and altitude loss that were obtained by the pilots who recovered successfully shows the positive effects of beginning the recovery in a timely manner.

It was surprising to note that the evaluation pilots who recovered successfully had

generated a smaller vertical g loading than those who did not recover successfully. Because the pilots who recovered did not obtain the Learjet's maximum certificated (limit) load, they could have obtained somewhat better performance (less altitude loss) during recovery by pulling pack harder on the column to obtain the limit load. However, this group of pilots generated enough vertical g loads, at the correct time, to recover successfully. The greater g load generated by the non-recovering pilots demonstrates how a single maximum value can misleadingly represent the time history of a force or control input during the entire recovery attempt. Based on their greater altitude loss and airspeed deviation, it is likely that the non-recovering pilots obtained their maximum-recorded g loads too late, just prior to a safety trip.

Shemya

This accident began with an uncommanded slat deployment, which caused the airplane to pitch up. The elevator control inputs that the flight crew made in response to this initial pitch-up induced nose-down and nose-up pitch oscillation cycles. The airplane type that was involved in the accident had relatively light elevator control forces, which were reproduced for this study's in-flight simulation of the event.

The critical elements in the recovery were: disconnect the autopilot, then recognize the extreme pitch sensitivity of the airplane and recover using small, infrequent, well-timed elevator inputs.

Results. Eleven percent of the evaluation pilots were able to recover from this scenario. There were no reliable differences between training groups with respect to recovery, nor with respect to any individual recovery elements.

All of the pilots who recovered managed to limit the magnitude of their pitch inputs, while all who failed to recover used normal size inputs. Three of the four evaluation pilots who recovered disconnected the autopilot prior to making their first elevator input, which avoided the need to use force to overpower the autopilot while making the required, sensitive elevator inputs. However, one pilot managed to recover with the autopilot engaged through the first 25 seconds of the event.

Safety trips terminated the recovery attempt for all who failed to recover. The most common reason for the safety trip was excessive positive or negative vertical g.

Discussion. The evaluation pilots' relatively low success rate in recovering from this scenario reflects the difficulty of the scenario. There were no salient cues to the impending upset, and the required sensitivity to elevator inputs had to be recognized immediately. In fact, comments by evaluation pilots and safety pilots indicated that, for best performance, the pilot would have been required to have *anticipated* the light pitch control forces and relaxed stability characteristics of this aircraft type in high altitude cruise flight. Failing that, pilots would have had to immediately recognize these control characteristics from the airplane's response to their first input, and then quickly back out of the control loop to avoid inducing worse pitch oscillations.

Another factor in the low recovery rate may have been the lack of training for most pilots, including most of these evaluation pilots, in upset recoveries that require a light, careful, and sensitive touch to the controls (note high altitude cruise is discussed in both the American Airlines' AAMP and United's AMP). Most upset recovery training normally stresses the need for maximum control inputs to obtain maximum aircraft performance. Of the training groups in this study, only the in-flight training group had been exposed to reduce stability margins in actual flight, with the ability for the evaluation pilots to feel the airplane response to pitch inputs and the g forces generated

by these inputs. None of the groups, including the in-flight training group, were able to obtain a high level of success in recovery or to perform significantly better than any other group. This indicates that pilots trained under any of these programs may not be well prepared to deal with an upset such as this one. Most pilots did not seem to have the knowledge or experience necessary to recover from this high-altitude airplane upset.

Nagoya

This maneuver was presented to participating pilots as an approach following behind a heavy wide-body aircraft, with a caution for wake turbulence. However, the underlying cause of the accident simulated was the application of full nose-up trim, resulting from conflicting inputs from the autopilot and first officer, combined with high thrust settings commanded by alpha floor protection and the decision by the Captain to go-around. This combination pitched the aircraft into aerodynamic stall. For the study, using a configuration of gear down and flaps 20 degrees at 150 knots, the aircraft was upset by allowing the autopilot to apply full nose-up trim, then disconnect, providing the pilot with excessive nose-up control forces.

The key steps in recovery from this scenario were to input full nose-down elevator. Then, recognizing that the available elevator authority was insufficient to control the airplane's nose-up pitching moment, apply emergency trim and/or roll the airplane to divert the lift vector from the vertical.

Results. Thirty-three percent of the evaluation pilots were able to recover from this scenario. There were no reliable differences between training groups with respect to recovery, nor with respect to any individual recovery elements.

Pilots who recovered differed from those who did not only in time to call for emergency trim. As a result, pilots who recovered encountered no safety trips, while two thirds of those who did not recover encountered safety trips (Learjet angle of attack safety trip). Pilots who recovered were not statistically faster to announce the problem, or apply correct control inputs.

On average, pilots responded by applying elevator within 5 seconds, with all but one applying full forward elevator. However, pilots were slower to announce the problem. Only 14% of evaluation pilots applied aileron to control the lift vector. Emergency trim was applied by less than half of the pilots. And those who applied trim took an average of 12 seconds to do so.

Discussion. As a group, pilots appeared to respond consistently with the training for nose-high attitudes that they had received since becoming a student pilot --nose-down elevator. However, the majority of pilots did not implement corrective actions that were additionally required for this accident scenario, resulting in safety trips for critically high angle of attack. That 86 percent of evaluation pilots did not roll the airplane to control the lift vector implies that the one-time training many had received in this alternative control strategy was not effective. Also, the majority was slow to recognize the need or call for emergency trim. One interpretation of these data is that understanding and correcting the underlying cause of the unusual attitude, which is unique to the scenario rather than generic to unusual attitude recovery, was critical to recovery. (It may be significant, though, that the aircraft normally flown by some of the evaluation pilots were not equipped with an emergency trim system similar to that installed on the Learjet; for these pilots, the briefing provided before the evaluation flight about the Learjet's emergency trim constituted minimal training on this system.)

This scenario contrasts with performance observed in the Toledo accident. That

event involved a nose-low and left wing-down attitude resulting from one pilot's spatial disorientation. There was no underlying mechanical or environmental cause for the upset and all but one pilot recovered. In Toledo, applying the normal control inputs solved the problem. In Nagoya, though, recovery occurred only with correction of the underlying runaway trim or use of large bank angle to supplement full nose-down elevator input. Airplane upset recovery training has focused on the recoveries from straightforward upset attitudes, rather than from upsets exacerbated by underlying malfunctions or other conditions that require alternatives to the application of normal control inputs. Two-thirds of the evaluation pilots failed to correct what was unique to the Nagoya scenario or proceed to a necessary alternative strategy to regain control.

Pittsburgh

This accident involved an uncommanded rudder deflection that led to a rapid yaw/roll to the left. The upset began with the airplane operating near the 'crossover speed' for the existing configuration; with any decrease in airspeed or increase in vertical g load, even a full wheel input (full aileron/spoiler deflection) could not overpower the yaw/roll moments from a deflected rudder.

The critical elements in the recovery from this upset were: apply full wheel input to oppose the yaw/roll, unload the pitch axis, and use split thrust inputs if required to regain roll control.

Results. Twenty-two percent of the evaluation pilots were able to recover from this scenario. There were no reliable differences between training groups with respect to recovery, nor with respect to any individual recovery elements. However, six of the seven members of the in-flight training group, all of whom recovered successfully, used split thrust. This technique had been covered explicitly in the in-flight training curriculum. This training group had also been exposed to a rudder hard over scenario.

Pilots who recovered differed significantly from those who did not only in thrust delta, which was an outcome of the split-throttle technique. Of the eight who recovered, one unloaded pitch and increased airspeed, five used split thrust inputs, and two used a combined airspeed/split thrust method. Only one of the eight exceeded 70 degrees bank angle prior to regaining roll control. A key error was failure to reduce the angle of attack after the initial full aileron control input did not render the desired effect. Very few of the evaluation pilots experienced safety trips since very few of the evaluation pilots put in enough of a rudder input to cause a safety trip. The safety trip did affect the recovery of the one evaluation pilot in the In-flight group who did not recover due to excessive AOA.

Discussion. This scenario involved an upset attitude exacerbated by the malfunction of a primary flight control. Further, the crossover issue (adequate roll control authority using roll control alone, could be obtained/maintained only by unloading pitch) is not intuitively obvious to pilots. This may explain the relatively low percentage of pilots who recovered from this scenario. The success of some pilots in using the split throttle technique highlights the importance of training in the use of secondary flight controls to enhance the effectiveness, or compensate for the failure of, primary controls. The ability of the in-flight group to successfully apply this technique shows a positive training effect, albeit with only a single day's break between training and testing. It is important to note that one evaluation pilot split the throttle incorrectly, actually worsening the upset. This result supports the hesitancy of some operators to incorporate split thrust in their recovery procedure for uncommanded yaw excursions.

Pilots who did not recover apparently lost less altitude (603 feet) than those who

recovered successfully (939 feet). This surprising result was an artifact of the termination of data recording when a recovery attempt ended with a safety trip. The result does imply that many of the pilots who failed to recover would have exceeded safe operating parameters relatively early in their recovery attempts (if not protected by the Learjet safety trip).

Roselawn

This maneuver was presented to the evaluation pilots as a descent in icing conditions. The underlying cause of the accident simulated was an uncommanded roll resulting from buildup of ice behind the leading edge de-icing boots on the wings. For the study, with landing gear up and flaps extended to 20 degrees, the aircraft was upset with an aileron snatch followed by an uncommanded roll simulating wing-ice induced stall.

The key step in recovery was to unload with nose-down elevator input. Throughout the recovery it was important to apply and maintain the nose-down elevator required to keep the angle of attack below the critical value at which the ailerons snatched.

Results. Forty-three percent of the evaluation pilots were able to recover from this scenario. However, nearly half of these were in the in-flight group, which was given training on a similar scenario in the aircraft prior to testing. There were no reliable differences between training groups with respect to recovery, nor with respect to any individual recovery elements. Differences between training groups in recovery were not statistically significant, even though half of the recoveries were in the in-flight group.

Pilots who recovered differed from those who did not in the maximum airspeed obtained in recovery. Pilots who recovered averaged 19 knots greater airspeed than pilots who did not recover.

On average, pilots responded by quickly applying correct aileron and rudder inputs, but were slow to apply nose-forward elevator to reduce angle of attack.

Discussion. As a group, pilots appeared to respond in accordance with their training for excessive bank and stall recovery, but did not implement corrective actions uniquely required for icing-induced stall and uncommanded control movement. In fact, these two types of stall recovery require different responses. Normal stall recovery training (which actually trains pilots in recovering from the approach-to-stall) tends to emphasize applying maximum power and minimizing loss of altitude. In contrast, recovery from icing-induced and other more complete stalls requires trading altitude for airspeed.

Detroit

This maneuver was presented to the participating pilots as a roll upset during approach in icing conditions. The underlying cause of the simulated accident was asymmetric lift due to icing. The key to recovery was to increase aileron effectiveness by reducing angle of attack and increasing airspeed.

Results. Forty-four percent of the evaluation pilots were able to recover from this scenario. There were no reliable differences between training groups with respect to recovery, nor with respect to any individual recovery elements.

Pilots who recovered differed from those who did not in maximum airspeed. On average, those who recovered reached a higher airspeed than those who did not. Even though no other differences were statistically reliable, it is interesting to note that on

average, those who recovered took more time on each of the measures (e.g., time to announce problem, time to first correct control input).

Discussion. The pattern of results in this scenario is very similar to that of the Roselawn scenario, which also involved icing-induced loss of lift, with the added complication of aileron snatch. Slightly less than half of the evaluation pilots recovered in either case. The comparison between those who were able to recover in these two events and those who did not recover underscores the importance of sacrificing altitude for airspeed, and the criticality of increasing airspeed and reducing angle of attack for effectiveness of control when surfaces are contaminated with ice.

Participating pilots in both the Roselawn and Detroit maneuvers commented on the inadequacy of standard stall-recovery training and conflict between their training for stall recovery and what was required in icing conditions. They described how standard training programs emphasize response to stick shaker and minimal loss of altitude. Stalls resulting from ice contaminated surfaces can occur at angles of attack well below stick shaker and in situations in which sacrificing altitude may be the only way to reduce angle of attack and gain airspeed quickly enough to recover.

GENERAL DISCUSSION

Characteristics of the accident scenarios accounted for most of the variance in recovery performance in the study. Most pilots in all five groups recovered successfully in two scenarios: Charlotte and Toledo. Charlotte was a windshear scenario. Most airlines now provide windshear training and all pilots in this study had received windshear training, perhaps repeatedly, outside of upset recovery training. Thus, the recovery data suggest that training for a specific scenario can be very effective. In the Toledo scenario, the pilots had to take control of the aircraft from an incapacitated captain and recover from a nose-low spiral. The recovery data suggest that most first officers would be able take control and recover from a nose-low, steep bank situation in which the cues are unambiguous.

The Charlotte and Toledo scenarios required textbook application of recovery techniques reinforced throughout pilots' careers, microburst and unusual attitudes, respectively. In both cases the airplane responded when the pilot used the flight controls in the normal way, as long as the pilot applied adequate control force to achieve the performance needed from the airplane. The recovery rate in these scenarios was extremely high, regardless of the type of upset recovery or aerobatic training received by the pilots.

In striking contrast, the Birmingham and Shemya accidents required application of recovery techniques that were essentially different from what has been trained throughout pilots' careers. In the Birmingham scenario (nose-high attitude induced by strong thunderstorm turbulence) many evaluation pilots appeared to be trying to execute a wind shear recovery. Applying those recovery techniques, a pilot would level the wings and hold near stick-shaker pitch; the control column force needed to maintain the desired pitch would vary from moment to moment depending on gusts, but the airplane would respond to the pilot's elevator inputs. But in this scenario, full nose-down column had to be applied and held. Then, immediately upon realizing that full nose-down elevator could not reduce the angle of attack, the pilot had to proceed to an alternative control strategy to prevent a stall, rolling the airplane to control its pitch attitude. . In the Shemya scenario (uncommanded pitch-up induced by slat deployment), the aircraft must be very gently controlled to recover from an uncommanded pitch excursion because of the

reduced aerodynamic damping caused by low air density at high altitude and the mach effect. Most airplane upset recovery training emphasizes aggressively moving the aircraft back to a straight and level attitude. That action leads to increasing oscillations about the pitch axis when applied in this scenario. The recovery rate in these two scenarios was extremely low. This is consistent with the complexity of the scenarios, the brief time available for applying the correct recovery inputs, and the far lesser degree to which the evaluation pilots' had obtained prior training and experience that was relevant.

In between are scenarios in which the textbook recoveries were ineffective because of underlying changes in normal control response that initiated the upset and also complicated the recovery attempt. In these, either pilot had to quickly understand the underlying cause of the upset and immediately adopt an alternative recovery procedure, or the standard recovery procedure had to be robust enough to be effective despite the altered control response. For example, the Detroit and Roselawn scenarios required positively reducing angle of attack, sacrificing altitude for airspeed during the recovery from an icing-induced stall or uncommanded roll off. This is inconsistent with the approach-to-stall training pilots have encountered throughout their careers, which emphasizes minimizing altitude loss. Pilots made proper aileron and rudder inputs in both cases but were slow to reduce angle of attack. Similarly, the Pittsburgh scenario required reducing angle of attack and reducing vertical g load to enable roll control effectiveness or the application of alternate mechanisms for roll control, because of a fully deflected and jammed rudder. Further, Nagoya required not only manipulating the controls toward an appropriate attitude, but also correcting an underlying configuration problem-- full nose-up trim. An alternative to correcting the trim was using roll to divert the lift vector from the vertical.

Recovery in these four scenarios ranged from 23 to 42 percent (five groups combined) and was unrelated to the type of airplane-upset recovery or aerobatic training pilots had received. Most pilots had difficulty transitioning to an alternative control technique when confronted with ineffective response from the normal controls or recovery procedures. It seems noteworthy that the six scenarios in which the majority of evaluation pilots failed to recover required reducing angle of attack.

This study provides valuable data about the kinds of error made by evaluation pilots in all five training groups while attempting to recover from the upset scenarios. Failure to reduce angle of attack and sacrifice altitude when required has already been noted.

For nose high scenarios the most common mistake was failing to use bank angle to change the direction of the lift vector as an alternative to the normal pitch controls. Many of the evaluation pilots had received at least some training to recover from a nose-high upset using bank angle, but this training did not appear to have been effective. Similarly, pilots also generally failed to use secondary controls to enhance recovery (e.g., split thrust to enhance roll control).

Most pilots in the Shemya scenario used overly aggressive control inputs. Aggressive inputs were consistent with most upset types and the associated recovery procedures, and few evaluation pilots appear to have received significant prior training or experience with the high altitude/high mach aircraft handling techniques that may have been more appropriate for recovering from Shemya and similar situations.

Pilots were inconsistent in pressing the autopilot disconnect button before applying recovery control inputs. The autopilot was engaged during entry into only the Shemya scenario, but disconnecting the autopilot is trained as an immediate recovery

action regardless of automation status (on most transport types). In the Toledo and Pittsburgh scenarios the great majority of pilots failed to disconnect the autopilot. Curiously, in the Shemya and Charlotte scenarios the great majority of pilots did disconnect the autopilot. In the Nagoya scenario slightly more than half of the pilots who recovered disconnected the autopilot, and those who disconnected it waited an average of 10 seconds after they tried to control the airplane's pitch-up with the elevator. We do not know why the evaluation pilots disconnected the autopilot in some but not other scenarios. The classroom upset training received by three groups of evaluation pilots heavily emphasized the importance of disconnecting the autopilot, but perhaps they had not practiced this action sufficiently for it to become an automatic, highly learned response resilient against surprise and confusion.

In general, evaluation pilots who failed to recover showed evidence of confusion and other stress reactions. In some cases, they seemed to freeze on the controls; in other cases they made rapid switches between power settings, inadvertently activated controls, or engendered roll oscillations. These confused reactions suggest that upset training should place greater emphasis on surprise and the initial encounter with conditions leading to upsets, rather than focusing entirely on practicing recovery techniques.

No statistically significant differences in recovery performance were found among the five training groups. However, as previously mentioned, because of the small number of pilots in this study and possible differences in previous experience among pilots, we cannot be certain that type of training (as received by these evaluation pilots) does not affect performance to some degree in some of the eight scenarios.

The evaluation pilots from all training groups showed substantial differences in performance, perhaps reflecting substantial differences in the amount and nature of their flight experience before being hired at their current airlines. For example, the number of scenarios in which individual pilots recovered ranged from zero to seven, with an average of 3.2 (out of eight). The variability in experience among the evaluation pilots reflects the current distribution in new-hires in U.S. airlines.

The evaluation pilots in this study who had received upset training in ground simulators were exposed to a single session of generic training. The upset recovery training currently provided by major airlines typically consists of four to eight hours of classroom training and a simulator session that takes a generic approach, teaching pilots methods to recover from nose-high, nose-low, and excessive bank situations, rather than attempting to address a wide range of upset scenarios specifically. It is not practical to anticipate and train for each of the enormous number of specific upset scenarios that might someday happen. In this study six scenarios presented evaluation pilots with unfamiliar situations for which they had not been specifically trained; many pilots reacted to these situations with confusion and were not able to recover. However, the results of the study suggest ways in which current upset recovery training might be expanded to help pilots deal with a wide range of unfamiliar situations:

1. While it is not possible to train for all conceivable situations, it should be possible to identify a relatively small number of classes of upset scenarios that might cover most situations and train for each of those classes of situation. For example, reducing vertical g load and angle of attack improves control response and airplane performance in the recoveries from many scenarios. This study has laid some of the groundwork for identifying the classes of upsets and relevant recovery procedures.
2. Classroom training can help pilots identify the cues for recognizing

conditions leading up to classes of upset and distinguishing the type of recovery required. Distinguishing between situations that superficially appear similar but require fundamentally different responses should be emphasized. For example, recovery from fully developed stalls should be distinguished from recovery from incipient stalls, and windshear recovery should be distinguished from nose-high situations that require reducing angle of attack aggressively.

3. Simulation training could place much greater emphasis on exposing pilots to conditions leading up to upsets and to the onset of upsets, so they can practice recognizing cues that distinguish different classes of upset. Further, if the situation makes it unlikely that pilots could identify the underlying factors in the upset, students can practice responding with control responses that are effective in recovering from a range of classes of upsets. Simulation training should also present upsets in unexpected ways so that pilots experience surprise and learn to deal with the initial confusion. This would require integrating upset training with other forms of training so pilots cannot always anticipate that they will face an upset.
4. Upset recovery training could be part of both initial qualification and recurrent training, which would provide recency of experience and reinforcement.

CONCLUSIONS

1. The new hire airline pilots in this study, with or without specific upset or aerobatic training, were well prepared to recover from a windshear encounter. Presumably this was because these pilots had received one or more sessions of classroom and simulator training in windshear recovery outside of upset training. Furthermore, the recovery technique for windshear is relatively straightforward.
2. These evaluation pilots, with or without upset or aerobatic training, were well prepared to take over control and recover from a nose-low spiral in which cues for the nature of the problem were unambiguous and which required large and aggressive control inputs.
3. Most of these pilots, regardless of upset or aerobatic training, did not recover from six of the eight upset scenarios. However a sizeable minority of pilots was able to recover from the Birmingham, Roselawn, and Detroit scenarios. The reader is cautioned that these scenarios are based upon actual fatal accidents in which the crews did not recover, and the correct recovery procedures were determined only after the accident by a panel of experts with considerably more time to analyze the situation. Recovery from these six scenarios requires pilots to recognize critical aspects of the situation in order to determine the correct recovery procedure. In at least two of the scenarios the correct recovery technique in some respects conflicted with well-learned recovery techniques for situations that superficially appear similar.
4. Substantial variability in performance occurred among pilots from all groups, perhaps reflecting differences in previous flight experience. The number of recoveries per pilot ranged from zero to seven out of eight.
5. The pilots in this study seem representative of first officers in their

probationary year in U.S. major and regional airlines. However, they are not representative of pilots highly experienced in the aircraft flown, nor are they representative of experienced captains. No conclusions can be drawn from this study about how well more experienced pilots might have been able to recover from these scenarios.

6. This study suggests that new-hire airline first officers may not be adequately prepared for some upset situations, even though they have received initial training in upset recovery of a generic nature. Further investigation will be required to explain this finding. One possibility is that a single training exposure is not adequate to enable pilots to recognize unique aspects of an upset situation and to respond quickly with appropriate inputs—especially since pilots have no chance to practice these recovery maneuvers in line flying. Another possibility is that some scenarios have unique features that are not adequately covered by generic training that addresses only nose-high, nose-low, and excessive bank conditions.
7. Airplane upset recovery training might be improved by increasing the complexity of events to which pilots are exposed and by integrating upset recovery training into qualification and recurrent training throughout pilots' careers.
8. Further research is warranted.

1. INTRODUCTION

This section of the document is divided into three parts, a description of: 1) airplane upset accidents, 2) airplane upset training, and 3) the process by which the evaluation of the airplane upset training was developed.

1.1 AIRPLANE UPSET ACCIDENTS

As a result of the public's concern about air safety, the Gore Commission was established to review the United States air transportation safety record and make recommendations as to how to improve safety. The commercial aircraft accident rate has now stabilized at 0.3 accidents/million departures but, with the projected growth in air travel, the number of accidents per year is projected to double in the next decade (Figure 1).[4]

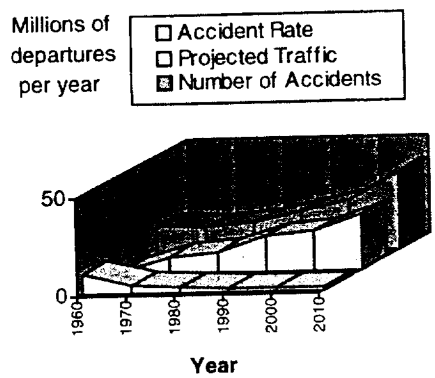

Figure 1. Aircraft Accident Statistics

Loss of control is the leading factor in hull losses and fatalities. "Loss of control refers to accidents resulting from situations in which the pilot should have maintained or regained aircraft control but did not"[5]. Loss of control accidents resulted in 2,359 fatalities 1991 through 2000 worldwide among airlines (see Figure 2)[6]. This is up from 2,221 fatalities that occurred 1987 through 1996 (see Figure 3). The majority of the loss-of-control <u>accidents</u> have been stalls (see Figure 4). Flight control accidents included failed attitude director, inadvertent slat deployment, autopilot failures, and rudder hardovers. Wake turbulence was the most frequently reported[7] factor in loss-of-control <u>incidents</u> (see Figure 5). Loss of control accidents were not limited to particular flight phases (see Figure 6) or aircraft (see Table 1).

4 M. Lewis, C. Huetner, <u>NASA Aviation Safety Program, Report to Industry</u>, August 13, 1997.
5 http://www.nbaa.org/@ @2ALvAi9OGgEC/safety/saferskies/lossofcontrol.htm
6 http://www.boeing.com/news/techissues/pdf/2000_statsum.pdf
7 NASA Aviation Safety Reporting System

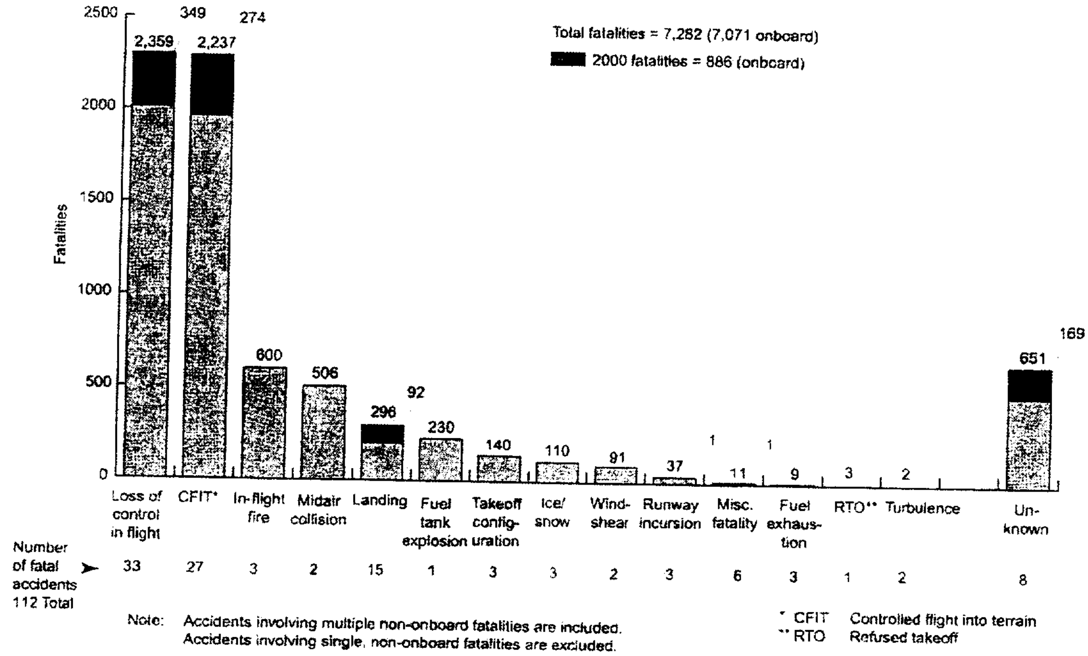

Figure 2. Fatalities by Accident Categories Worldwide Commercial Jets 1991 Through 2000[8]

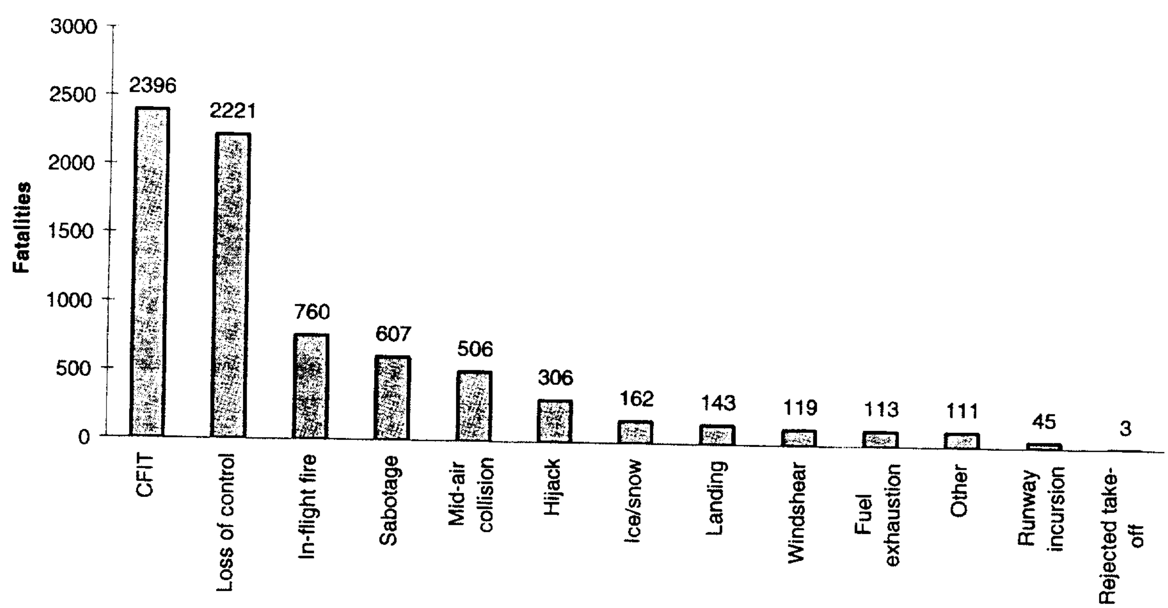

Figure 3. Worldwide Airline Fatalities By Type, 1987 To 1996[9]

8 http://www.boeing.com/news/techissues/pdf/2000_statsum.pdf
9 Airplane Upset Recovery Training Aid, 12 May 1998.

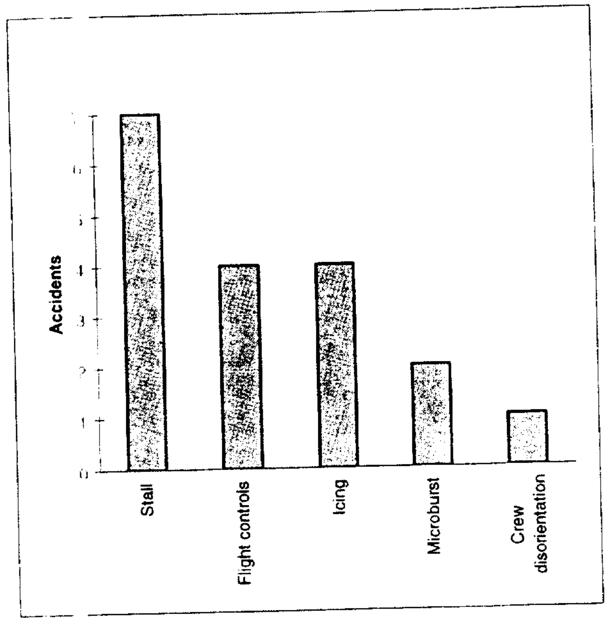

Figure 4. Loss-Of-Control Accidents, 1986 To 1996[10]

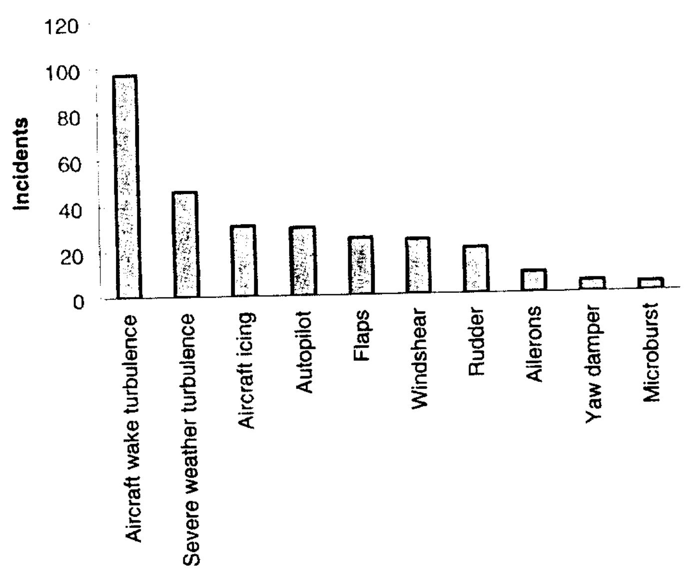

Figure 5. Multi-Engine Turbojet Loss-Of-Control Factors, 1987 to 1996[11]

10 NTSB Analysis of 20 Transport Category Loss-of-control Accidents, 1986 to 1996.
11 NASA ASRS Multiengine Turbojet Loss-of-Control Factors, January 1987 to May 1995.

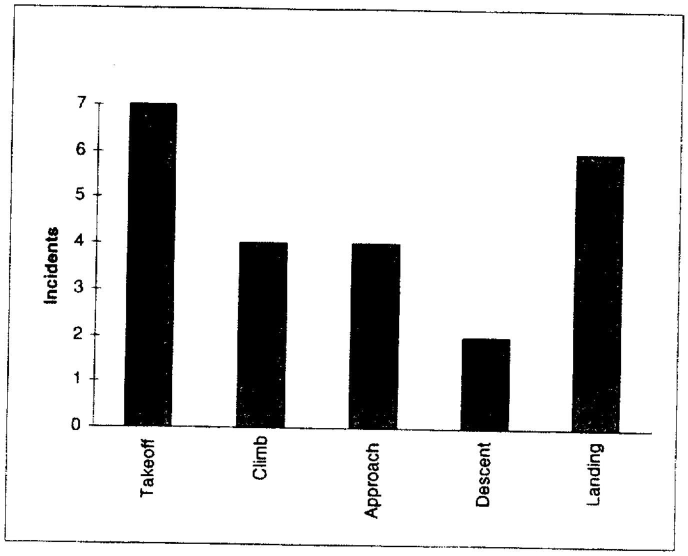

Figure 6. Multi-Engine Turbojet Loss of Control Incidents By Flight Phase[12]

Table 1. Multi-Engine Turbojet Loss of Control Accidents By Aircraft[13]

Aircraft	Frequency	Aircraft	Frequency
B737-300	5	DC-9-30	1
B737-200	4	DC-9-80	1
B737	3	DC-9-80	1
Beech 1900	3	DH8-100	1
B727-200	2	E120	1
B757-200	2	Falcon 50	1
DC-9	2	Fokker 100	1
MD-82	2	Jetstar 1329	1
A320	1	Learjet 25	1
B747	1	Learjet 35	1
B747-100	1	Learjet 60	1
B757-500	1	MD11	1
BAE 4100	1	MD88	1
Citation 5	1	PA-31	1
CL65	1	SF 340A	1
DC-9-10	1	SJ30	1

One type of loss of control is an airplane upset. Airplane upsets are defined as "an airplane in flight unintentionally exceeding the parameters normally experienced in line operations or training."[14] The parameters are "pitch attitude greater than 25 degrees nose up, pitch attitude greater than 10 degrees nose down, bank angle greater than 45 degrees, or within the above parameters but flying at speeds inappropriate for the

12 NASA ASRS Multiengine Turbojet Loss-of-Control Factors, January 1987 to May 1995.
13 NASA ASRS Multiengine Turbojet Loss-of-Control Factors, January 1987 to May 1995.
14 Airplane Upset Recovery Training Aid, 12 May 1998.

conditions."[15] Although airplane upsets do not happen often, an estimated one in seven million departures[16], they can be deadly.

1.2 AIRPLANE UPSET TRAINING

In an attempt to reduce the number of Airplane Upset Accidents, the US National Transportation Safety Board (NTSB) has issued numerous recommendations to the US Federal Aviation Administration (FAA) regarding training of pilots. For example in 1971, NTSB Safety Recommendation A-72-152[17] recommended that the FAA to amend 14 CFR 61 and 121 to "include a requirement for pilots to demonstrate their ability to recover from abnormal regimes of flight and unusual attitudes solely by reference to flight instruments. For maximum safety, these demonstrations should be conducted in an appropriate flight simulator. Should existing or proposed simulators be incapable ... the FAA [should] take appropriate measures to require that such existing or proposed simulators be replaced or modified to include such a capability." In August 1995, the FAA issued a bulletin that strongly suggested air carriers include in their flight training programs rare, potentially life-threatening events that could lead to loss-of-control and an accident.[18] More recently the Air Transport Association recommended, "The need for pilots and carriers to detect and correct anomalous autoflight performance" (Human Factors Committee, Automation Subcommittee, Air Transport Association (ATA)). Although this additional training is not mandatory, most major US carriers have voluntarily incorporated it into their curricula.[19,20] Available training is either ground-based simulation alone or with aerobatic flight or in-flight simulation.

1.2.1 Ground-based Simulation

Most airline upset training programs use classroom lectures complemented with ground-based simulation. For example, Captain Warren Vanderburgh of American Airlines developed an airplane upset training program, entitled Advanced Aircraft Maneuvering Program (AAMP), which starts with an eight-hour class discussing aerodynamics, unusual attitude recovery procedures, automation dependency, and the AAMP implementation plan. The class is given to all new hires and is also available on videotapes as refreshers for all American Airlines pilots. AAMP also includes ground-based simulation training. This simulation includes profiles designed to develop and reinforce specific flying skills. The profiles are: high angle-of-attack maneuvering demonstration (not a full stall), nose high and nose low unusual attitudes, a demanding level microburst, engine failure at low altitude and low energy, a Ground Proximity Warning System (GPWS) mode 2 'terrain', and fleet specific high altitude upset. The profiles are integrated into each fleet transition and recurrent training syllabus.

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15 Airplane Upset Recovery Training Aid, p. 1.1.
16 Forsythe, D. Airplane Upset Recovery Training, FSF 50th IASS, IFA 27th International Conference and IATA, Washington, DC, November 1997.
17 NTSB Safety Recommendation A-72-152, 31 March 1971, (updated 8 November 1994)
18 FAA Order 8400.10 Appendix 3, Selected Event Training, Flight Standards Handbook Bulletin (HBB) for Air Transportation (HBAT), Bulletin Number HBAT 95-10, , 16 August 1995.
19 W.B. Scott, United Pilots Practice Advanced Maneuvers, Aviation Week and Space Technology, March 27, 1995.
20 Manningham, Bruce Training for Upsets, Business and Commercial Aviation, November 1998.

At United Airlines the Airplane Upset Training is included in the Advanced Maneuvers Program[21]. The materials includes a review of the accident data and a description of the causes of airplane upsets including environment (turbulence, icing, and wake turbulence), systems anomalies (flight instruments, autoflight systems, flight controls), and human factors (distraction, vertigo). This classroom material is followed by ground simulation training.

Delta recently implemented the Critical Aircraft Situational Training (CAST) program. CAST includes both home study and simulator training. The home study material is succinct (five pages) and describes the importance of the training, the definition of airplane upsets, a discussion of aerodynamics related to upsets (e.g., angle of attack, lateral control, dihedral, bank angle), and recommended nose high and nose low recovery techniques. "Energy state Situational Awareness" is emphasized. Simulator training includes airplane-upset profiles that are tailored to each fleet aircraft and simulator capabilities. The profiles were developed to meet five training objectives: 1) identify aircraft handling characteristics at, near, and below[22] Vstall, 2) identify specific roll characteristics in normal flight at intermediate to high angle of attack, 3) identify pitch characteristics in normal flight at intermediate angle of attack, 4) identify specific yaw characteristics in normal flight at intermediate angle of attack, and 5) identify specific upsets (nose high and low) and apply correct recovery procedures and control inputs in intermediate to high angle of attack[23].

US Airways has implemented an Airplane Upset Recovery training program. Although there is no formal academic program, relevant material is covered in simulator training prebriefings for which students are expected to read the material provided, discuss it with their instructor, and then go fly it in the simulator. For this initial training, both pilots in the simulator receive both a nose low and a nose high recovery at the end of their simulator session. Each pilot does at least two rudder hardover recoveries – one on approach and one on takeoff. Airplane upset recovery is included in all transition training and is provided in the ground simulator. US Airways considers itself to be the leader in rudder hardover training and procedural implementation. This has been and continues to be a focus item in all training on the Boeing 737 aircraft. Specifically each Captain and first officer repeats the rudder hardover training every six months. Other types of airplane-upset recoveries are not repeated. These simulators are owned by the airline and have been programmed for specific events. Additional simulators are rented on an "as needed" basis and cannot be so programmed. US Airways instructors receive specific airplane upset recovery training. Their syllabus includes topics for discussion, instructions on using the ground simulator for recovery training, lesson goals, and past performance problems.

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21 United Airlines Advanced Maneuvers Program Study/Reference Guide, January 2000.

22 We do not feel the Sims can be considered accurate platforms at energy states (read that airspeeds) on the back side of the power curve. We teach if you are in a stall you must first break the stall (unload) and then maneuver to recover. In all cases we teach protect the lift vector (break the stall, then maneuver to point the lift vector opposite gravity). Our presentation methodology always uses the term " approach to stall " as it concerns setup in the Sim. We even do "accelerated approaches to Stall" that is turning and pulling at the same time. At all times we attempt to stay on the front side of the L/D curve.

23 Captain John Wittmeyer (Delta Airlines). Critical Aircraft Situational Training. 1 October 1999.

The cost to an airline for in-situ flight training is high since it includes not only the flight operations cost of the aircraft but also, the lost revenue or fixed capital cost of a dedicated airliner for training and the risk of an accident.[24] However, there is some concern that the ground-based simulation may provide false or improper cues and lead to negative transfer-of-training especially in large amplitude, highly dynamic maneuvers such as airplane upsets.[25,26,27] In response to these concerns, two airlines, Cathay Pacific and SAS have initiated aerobatic training in addition to ground-based simulation.

1.2.2 Aerobatic Flight

SAS started a program in the summer of 1999 in which their pilots receive both simulator and aerobatic airplane upset training. Their program is presented in Table 2. The aircraft used is the Saab 91D, Safir. It is a four passenger, aerobatic, single engine, propeller aircraft. It has retractable tricycle landing gear. The weight limit is 2450 pounds for aerobatic flight. Further the two rear seats are not used during aerobatic flight.

The SAS program targets new hires. This is critical since as Ray[28] (1999) stated "most airline pilots rarely experience airplane upsets during their line flying careers. It has also indicated that many pilots have never been trained in maximum-performance airplane maneuvers, such as aerobatic maneuvers, and those pilots who have been exposed to aerobatics lose their skills over time". As an alternative, a change to the Air Transport Pilot (ATP) licensing has been proposed by several airlines and the ATA, specifically that aerobatic experience such as that described above be mandatory as part of the ATP licensing. To date there has only been one evaluation of aerobatics combined with simulation training. Doug Schwartz, while at Flight Safety International, provided aerobatic training to one pilot and then assessed the pilot's aircraft upset recovery performance in flight. Schwartz judged that the pilot completed better aircraft recoveries after the aerobatic training than before the aerobatic training[29]. Obviously there is concern on the generalizability of the results based on the data from one pilot. However, there are no other data available only expert opinion[30],[31] and qualitative assessments[32],[33] that aerobatic training enhances airplane upset recovery.

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24 Ray (1999) cited accidents from 1962 to 1972 in which forty-four lives lost and nine aircraft were destroyed performing required flight training.
25 Gawron, V.J. and Reynolds, P.A. "When In-Flight Simulation is Necessary," Journal of Aircraft, Volume 32, Number 2, 1995, 411-415.
26 Gawron, V.J., Bailey, R., and Lehman, E.: "Lessons Learned in Applying Simulators to Crewstation Evaluation," The International Journal of Aviation Psychology, Volume 5, Number 2, 277-290, 1995.
27 Roscoe, S.N., Jensen, R.S., and Gawron, V.J.: "Introduction to Training Systems." In S.N. Roscoe (Ed.) Aviation Psychology, Ames, Iowa: Iowa State University Press, 1980.
28 Ray, P. Quality Flight Simulation Proper and Improper Applications. 1999.
29 Personal communication Doug Schwartz (AT&T, 1 September 1999).
30 Davisson, B.: "What Can Aerobatics Do For You?" Air Progress, 1980, 42, 20 – 72.
31 Ethell, J.: "Upside Down is Rightside Up" Air Progress, 1986, 48, 51 – 77.
32 Brown, D.: "Introduction to Flight Testing Using an Aerobatic Trainer," Society of Automotive Engineers and American Institute of Aeronautics and Astronautics World Aviation Conference, 1999, Paper 1999-01-5534.

Table 2. Scandinavian Aviation College Advance Aircraft Handling Course[34]

4. GROUND TRAINING

Instr. unit	*Title and objectives*	*Hours*
EA-1	GROUND LESSON # 1	1:20
	1. Introduction to the course, aims, and general procedures	
	2. Discussion of the effects of G forces on the airplane and pilot.	
	3. Discussion of limit load factors on normal, utility, and aerobatic airplanes.	
	4. Pilot physiology, probable G forces to be encountered, and how to counteract them.	
	5. Preflight check of the airplane with special emphasis on checking for any structural damage.	
	6. Briefing of the parachute and procedures in exiting the aircraft.	
	7. Introduction to initial maneuvers and common errors: *Lazy eight, Chandelle, Aileron roll, Loop*	
EA-2	GROUND LESSON # 2	1:20
	1. Review of *Lazy eight, Chandelle,* and *Aileron roll*	
	2. Introduction of the *Loop*, the maneuver as a whole, step-by-step procedure and common errors. The effect of gravity on the maneuver.	
	3. Recoveries from unusual attitudes, different types, and procedures	
	4. Discussion of spin theory; airplane spin certification, factors that affect spin characteristic.	
	5. Introduction of: *Split S, Barrel roll, Cuban eight, Cloverleaf, Stall turn, Immelmann*	
EA-3	GROUND LESSON # 4	1:20
	1. Airplane certification and categories.	
	2. Discussion of maneuvering and gust envelops.	
	3. Discussion of airspeed indicator markings.	
	4. Discussion of the effect of aircraft weight on performance.	
	5. Energy management, how to put maneuvers together, and how to quickly assess your energy level.	
	6. Aerobatic with variable pitch propeller.	

5. FLIGHT TRAINING

Instr. unit		*Title and objectives* *Dual/Solo*	*Sorties* *Dual/Solo*	*Hours*
A.1	ADVANCED MANEUVERS (MFI 15)	1/0	0:40/ 0:00	
	1. The following maneuvers will be demonstrated and practiced A. Area orientation B. Steep turns (45°/60°) C. Unusual attitude (nose low) D. Lazy eight E. Chandelle' F. Aileron roll 2. Energy management will be emphasized during the whole sortie			

Instr. unit		*Title and objectives* *Dual/Solo*	*Sorties* *Dual/Solo*	*Hours*
A.2	ADVANCED MANEUVERS (MFI 15)	1/0	0:40/0:00	
	1. The following maneuvers will be practiced A. Maneuvers previously introduced and practiced 2. The following maneuvers will be introduced and practiced: A. Loop, B. Spin prevention and recovery, C. Unusual attitude (nose high)			

Instr. unit		*Title and objectives* *Dual/Solo*	*Sorties* *Dual/Solo*	*Hours*
A.3	ADVANCED MANEUVERS (MFI 15)	1/0	0:40/0:00	
	1. The following maneuvers will be practiced: A. Maneuvers previously practiced, B. Unusual attitude (nose high, nose low) 2. The following maneuvers will be introduced and practiced: A. Split S, B. Barrel roll			

Instr. unit		*Title and objectives* *Dual/Solo*	*Sorties* *Dual/Solo*	*Hours*
A.4	ADVANCED MANEUVERS (MFI 15)	1/0	0:40/0:00	
	1. The following maneuvers will be practiced: A. Maneuvers previously introduced and practiced 2. The following maneuvers will be introduced and practiced: A. Unusual attitude (inverted), B. Cuban eight, C. Cloverleaf 3. The student will be expected to practice recoveries at any time during the lesson.			

Instr. unit	*Title and objectives*	*Sorties* *Dual/Solo*	*Hours* *Dual/Solo*
A.5	ADVANCED MANEUVERS *(MFI 15)*	*1/0*	*0:40/6.00*
	1. The following maneuvers will be introduced and practiced: A. Immelmann, B. Stall turn		

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[33] Eastlake, C.N.: "Basic Aerobatics on Video as an Introduction to Stability and Control," American Institute of Aeronautics and Astronautics 38th Aerospace Sciences Meeting and Exhibit, 2000, Paper A00-16642.

34 With the kind permission of Hans Nyman (SAS)

2. During this lesson emphasize to be put on the over the top maneuvers. The student should develop a feel and confidence in the maneuvers, as well as develop an understanding of recovery techniques during critical phases of the maneuvers. Recoveries to be practiced during the maneuvers.
3. Student shall at this stage be able to assess the aircraft's energy level, and make correct decisions about recovery technique to be used during advanced maneuvers.
4. The profile of this lesson will be to fly through all the maneuvers practiced up to now. Pertinent instructions will be given by the instructor whenever needed. Any maneuver where problems are experienced will be practiced by the student, and commented upon by the instructor.

Rick Stowell developed another program. It is called the Emergency Maneuver Training (EMT®) program[35]. EMT consists of the following three modules: I stall/spin awareness, II in-flight emergencies, and III basic aerobatics. The lessons within each module include about 0.7 to 0.8 hours instruction and 0.7 to 0.8 hours flight. Module I lessons are: 1) basic aerodynamic principals and in-flight coordination exercises including turns, slow flight, and stalls; 2) the mechanics of one and two-turn spins; 3) precision one-turn spins including recovery from inadvertent spins entered from unusual attitudes; and 4) stall/spin awareness and spiral recovery. Module II lessons include: 1) full and half aileron rolls and inverted flight; 2) usual attitude recoveries; 3) slip and skid dynamics; and 4) control failures and simulated off airport landing scenarios. Module III lessons include: 1) aerodynamics of full and half loops as well as Immelmann; 2) half and reverse half Cuban Eights, Hammerhead Turns, and stall/spin; 3) design considerations for aerobatics; and 4) inverted turn dynamics, inverted spins, and inverted Dutch Rolls.

Don Wylie, president of Texas Air Aces, developed a shorter program. [36] The program is called Advanced Maneuvering Program (AMP) and was designed to let pilots experience g loads and the physiological effects (e.g., tunnel vision and heavy limbs) of airplane upsets. The program begins with half a day of lecture on aerodynamics and airplane upset accidents. During the next day and half four one-hour flights are given with extensive pre- and post-flight briefings. Although there are no quantitative data on the effectiveness of the program, a student stated "for anyone who hasn't been over on their back, it should almost be mandatory". Problems of generalizability of visibility and responsiveness of T-34 to transport category aircraft have been raised, however.

1.2.3 In-flight Simulation

The last type of airplane upset training uses an instrumented in-flight simulator, the Veridian Variable Stability Learjet (see Figure 7). As the need for upset recovery training for airline pilots was being voiced, it has become clear that in-flight simulator (IFS) aircraft have advantages for this purpose. Their value lies in the capability to accurately duplicate the characteristics of a variety of transport aircraft each with its own unique characteristics and potential failure modes and in the capability to recreate upset scenarios with the high level of repeatability needed for training all in an environment similar to transport category aircraft normally flown by the trainee. "Conducting upset training in actual flight has a number of advantages. First, the dynamic cues (aircraft motion) are real and undistorted and the startle factor is very significant. The gs are

35 Stowell, R. Training course outline – training syllabus. Van Nuys, CA, 28 March 1994.
36 Bradley, P. Upset Recovery Training: In- aircraft training is becoming more common as pilots attempt to prepare themselves to handle the unexpected. Business & Commercial Aviation November 1998; p. 87; Vol. 83, No. 5.

actual (most importantly, the unloading[37], or negative gs). The effects of the motion dynamics of the situation are maximized. And finally, the pilot gets a real sensation of physical danger."[38] Veridian's Airplane Upset Recovery Training program is presented in Appendix A.

Figure 7. Learjet Model 25 IFS

1.2.4 Summary

Three types of airplane-upset training are being used: ground-based simulation, aerobatic training, and in-flight simulation. Each has its strengths and weaknesses (see Table 3). The false cues in ground simulators that may be associated with out of the normal envelope flying are being addressed in a NASA project to provide more accurate aircraft dynamic models. Aerobatic flight is done in aircraft with handling and performance characteristics profoundly different from large swept-wing jets but the experience of the effect of g on a pilot's ability to reach and manipulate controls are difficult to demonstrate in a ground simulator. In-flight simulation is done with an aircraft with displays and controls quite different from those in the particular aircraft an airline pilot normally flies. Thus the pilot's habitual monitoring and airline-specific operating procedures may be disrupted. Also ground simulation allows upsets to be presented in the context of a complete normal flight that would be costly in the in-flight simulator.

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[37] Unload is defined as "reducing the angle of attack" Airplane Upset Recovery Training Aid, 12 May 1998, p. 2.38.

38 Rogers, R.J. Aircraft Upset Training. Air Line Pilot, May 1998, pp. 28 - 31.

Table 3. Review of Airplane Upset Training Options

Option	Strengths	Weaknesses
Ground-based Simulation	Duplicates precise flight deck and procedures. Enables airplane upsets to be introduced during a complete normal flight. Designed to develop and reinforce procedural skills and target behavioral responses. Least cost of all three options.	Some concern that aerobatic flying skills will degrade over time. Some concern for false or improper cues especially for airplane upset conditions.
Aerobatic Flight	Designed to develop aerobatic flying skills and awareness of extreme attitudes and flight characteristics.	Some concern that aerobatic flying skills will degrade over time. Concern that aerobatic aircraft are not representative of airline transport aircraft and required pilot skills and techniques.
In-flight Simulation	Most realistic reproduction of the feel of the flight dynamics. Also, designed to duplicate transport aircraft and potential failure modes in the air. Can duplicate actual aircraft scenarios in the air.	Some concern that aerobatic flying skills will degrade over time. Some concern that aircraft displays and controls differ from those pilots normally fly. Highest cost of all three options.

Perhaps even more important than the type of platform is the content of training, especially the type and amount of practice pilots receive in recovering from upset attitudes. To date, no formal evaluation of the effectiveness of existing airplane upset-training programs has been conducted. No data currently exist demonstrating how well airline pilots are able to respond to various airplane-upset scenarios. Nor have empirical studies examined the effectiveness of different approaches to training content.

1.3 OBJECTIVES

The primary objective of this study was to generate data to support decision-making on the part of the FAA and the airlines; specifically:

To compare the relative effectiveness of no training, aerobatic training (in light aircraft), ground simulation, combined aerobatic and ground simulation training, and in-flight simulation training on airplane upset recovery;

To determine how well currently trained, new-hire airline pilots are able to respond to a representative set of prototypical airplane upset scenarios;

To identify any specific weakness in pilots' recovery techniques and to identify areas in which current training should be improved; and

To determine whether some types of airplane upset scenarios are more difficult to recover from than others.

The decision making on the part of the FAA is broader than just rulemaking though the study could eventually have an effect on Federal Aviation Regulation (FAR) 121 and Appendix E and F, FAR 61, the Practical Training Standards (PTS), and Advanced Qualification Program (AQP). However, the best chance for near term positive intervention may be through FAA policy material (such as an FAA Advisory Circular on the subject and in any related revision to FAA Orders such as 8400.10). The decision making on the part of airlines is how best to spend their training dollars. The process for developing an evaluation plan that would meet these diverse objectives is described in the following section.

1.4 PROCESS OF DEVELOPING THE EVALUATION PLAN

The steps in developing an evaluation that met the needs of the airlines in providing the most effective training and the FAA in mandating training were: 1) develop a draft evaluation plan based on unusual attitude recovery research, 2) coordinate with ongoing research efforts within NASA, 3) distribute the draft evaluation plan to individuals and organizations involved in the development of the Airplane Upset Training Aid, 4) revise the draft evaluation plan at a workshop, 5) identify upset accidents through a literature search, 6) request a list of recoverable airplane upset accidents from Boeing, 7) request data for these accidents from NTSB, 8) identify correct recovery procedures for these selected accidents, and 9) select accidents that were hull loss and involved fatalities, were recoverable (as judged by a panel of experts after the accident), occurred in current aircraft, covered all types of accidents (see Figure 4) and all phases (see Figure 6).

1.4.1 Unusual Attitude Recovery Research

Failure to recognize and recover from unusual attitudes has been a problem plaguing military aircraft since their first use in World War I. To alleviate this problem, the Department of Defense, in general, and the Air Force, in particular, have developed and evaluated flight symbology designed to enable pilots to quickly identify aircraft attitude. While the majority of the effort has been focused on fighter aircraft,[39] a recent study focused on C-141 transport aircraft cockpit display symbology.[40] In this study, Air Force pilots were required to perform an Unusual Attitude Recovery (UAR) task consisting of an automatic set-up maneuver followed by manual recovery. To set-up the UAR, the test aircraft automatically flew a pre-programmed "masking" maneuver. The maneuver essentially hid the UAR initial condition (IC), which was a predefined target attitude (pitch and bank angle) and airspeed (Table 4). The masking maneuver was similar for each UAR set-ups. The masking maneuver lasted 15 to 25 seconds and terminated at the desired IC.

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39 Bailey, R.E.; Knotts, L.H.; Priest, J.E.; Gawron, V.J.; Parada, L.O.: "Evaluation of Proposed USAF HUD Standard, Session II," Calspan Report No. 7738-14, February 1993.
40 Bailey, R.E., Gawron, V.J., and Priest, J.E. "Final Report: TIFS/C-141 Display Upgrade Program," Calspan Final Report No. 8184-7, September 1994.

Table 4. Unusual Attitude Initial Conditions

UAR Number	Initial Flight Condition Pitch Attitude (deg)	Roll Attitude (deg)	Airspeed (KIAS)
1	+15	+15	180
2	+15	-60	180
3	-10	-30	230
4	-10	-45	230
5	-10	+60	230
6	-20	+30	230
7	-20	+45	230
8	-20	-60	230

UAR procedures, consistent with standard AFM 51-37 procedures, were briefed to each subject. However, since specific recovery procedures are only generally defined in AFM 51-37 for transport-type aircraft, more "formalized" recovery procedures were used to support quantitative analysis of UAR inputs. The subjects were trained during ground simulations on these recovery procedures. For nose-high UARs, the subjects were instructed to roll in the shortest direction to 45 degrees of bank, allow the nose to "slice" to the horizon, and recover to wings level. For nose-low UARs, the subjects were instructed to roll wings-level and "pull" to the horizon. Throttles were to be advanced for nose-high attitude ICs; conversely, throttles were to be retarded for nose-low attitude ICs. The UAR scoring parameters were also briefed. The time to initiate correct pitch, roll, and thrust inputs was graded, in addition to the "correctness" of the recovery inputs. Time to recover to wings-level was not graded so excessive 'g' was not to be used. Normal acceleration between 1.5 and 2.0 g was expected in the recovery.

The objective data from the UARs were analyzed using Multivariate Analysis of Variance (manova). There was no significant difference in reaction time (RT) for UAR (Hotellings T (35, 407) = 0.218, p = 0.992). There was a significant effect of pilot, however (Hotellings T (25, 407) = 8.760, p = 0.000) for all five RTs. Pilot 1 had the longest pitch RT (3.1 seconds), Pilot 5 the shortest (1.1 seconds). The same results occurred for roll RT, throttle RT, and fastest correct RT (Pilot 1 – 1.5 seconds; Pilot 5 – 0.7 seconds). Although Pilot 1 still had the longest incorrect RT (2.5 seconds), Pilot 2 had the shortest (1.5 seconds). The interaction of UAR and pilot was not significant (Hotellings T (140, 407) = 5.468, p = 0.000).

Another manova was calculated for percent correct pitch, roll, and throttle control inputs. There was a significant UAR effect (Hotellings T (21, 305) = 7.352, p = 0.000) (see Figure 8). There was also a significant pilot effect (Hotellings T (15, 305) = 2.539, p = 0.000) with variations between 70 and 100% correct among pilots.

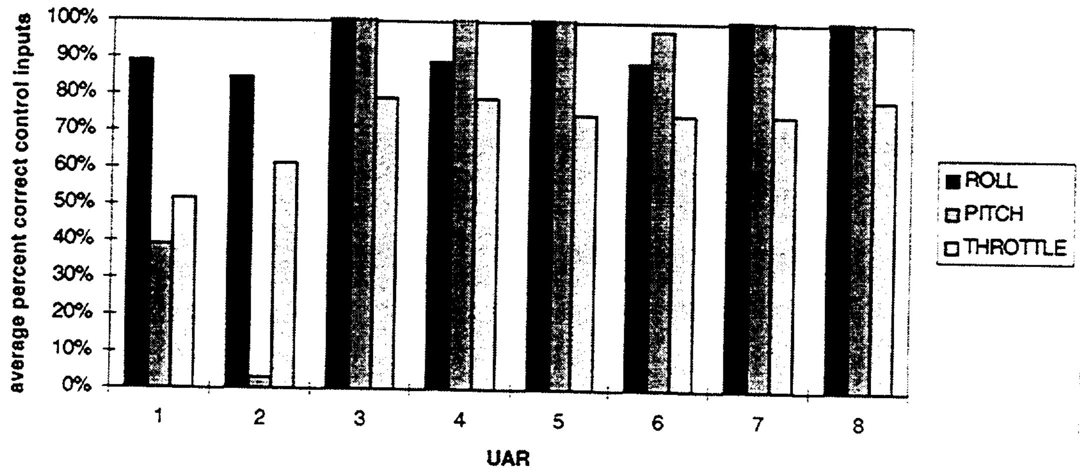

Figure 8. Interactive Effect of UAR and Axis on Average Percent Correct Control Inputs[41]

Based on these results, a set of initial conditions was developed as well as an initial list of dependent variables for the airplane upset training evaluation.

1.4.2 Airplane Upset Research Within NASA

Mary Shafer (NASA/Dryden) began a test program to evaluate the effectiveness of aerobatic flight on Airplane Upset Recovery. Her interest was focused on a comparison of the effectiveness of aerobatic training on new hires at airlines with and without prior military experience. Since all military pilots receive aerobatic training, she expected a significant difference in confidence to recover airplanes between new hires with and without military experience. She hypothesized that the aerobatic training in the NASA F/A-18 would equalize these groups. Veridian originally proposed to collaborate with NASA/Dryden to obtain a more comprehensive and complete examination of airplane-upset recovery training requirements. This was not done due to funding shortages at NASA Dryden.

NASA/Langley modified and operates a Boeing 757 aircraft. The aircraft is typical of airline assets and has a complete data collection package making it an excellent test bed. Veridian originally proposed to collaborate with NASA/Langley to use this aircraft to evaluate airplane upset recovery training options. This was not possible due to the initial conditions selected for the evaluation scenarios. NASA (correctly) estimated that to be significantly representative, the B-757 would have to achieve pitch and roll attitudes that could result in exceeding the aircraft's structural flight envelope, especially during the recovery phase.

[41] The second UAR scenario was +15 degrees pitch, 60 degrees left bank, and low airspeed. The tendency was to let the nose slice by itself as stated in the Air Force Manual 51-37, while nose forward input would have facilitated the recovery even more so.

1.4.3 Airplane Upset Training Aid Consortium

A consortium of airplane manufacturers, airlines, pilot associations, flight training organizations, and government regulatory agencies developed the Airplane Upset Training Aid. The Aid is available on Compact Disc (CD) and contains text, slides, and videos. In the Aid, an airplane upset is defined as: pitch attitude greater than 25° nose up, pitch attitude greater than 10° nose down, bank angle greater than 45°, or within the above parameters but flying at airspeeds inappropriate for the conditions. The Aid includes a pilot guide to airplane recovery, spanning causes such as environmental conditions and system anomalies, swept wing aerodynamic fundamentals, and actual recovery maneuvers. It also includes an example airplane recovery-training program with academics, simulator training exercises (see Table 5), and recurrent training exercises.

Table 5. Simulator Training Exercises from Training Aid

Exercise 1. Nose-High Characteristics (Initial Training)
Exercise 1. Iteration One—Use of Nose-Down Elevator
Exercise 1. Iteration Two—Use of Bank Angle
Exercise 1. Iteration Three—Thrust Reduction (Underwing-Mounted Engines)
Exercise 2. Nose-Low Characteristics (Initial Training)
Exercise 2. Iteration One—High Entry Airspeed
Exercise 2. Iteration Two—Accelerated Stall Demonstration
Exercise 2. Iteration Three—High Bank Angle/Inverted Flight
Exercise 3. Optional Practice Exercise
Exercise 3. Instructions for the Simulator Instructor
Recurrent Training Exercises

The Airplane Upset Training Aid Consortium was the first group to review the draft evaluation plan developed in step 1 and described in Section 1.3.1. This group also identified additional personnel to review the document as well as to invite to the workshop.

1.4.4 Airplane Upset Training Evaluation Planning Workshop

The workshop was held during the International Symposium on Aviation Psychology held in Columbus, Ohio on 3 May 1999. Dr. Dick Jensen, the Ohio State University coordinator, made facilities available for the workshop. Twenty-four people representing 15 different organizations participated in the workshop (see Table 6). Another 75 people were sent the slides and the draft evaluation plan for comment. All but two did. In all, 31 organizations (3 aircraft manufacturers, 13 airlines, 2 pilot associations, 2 air transport associations, 3 regulatory agencies, 4 pilot training companies, 3 research agencies, and the NTSB) participated.

Table 6. Planning Workshop Participants

Name	Affiliation
Rockliff, Larry	Airbus
Rogers, Ron	ALPA
Chidester, Tom	American Airlines
Vanderburgh, Warren	American Airlines
Cashman, John	Boeing
Legrand, Jeff	Bombardier Aerospace
Marquis, Carl	Bombardier Aerospace
Tullo, Frank	Continental
Guckian, Jim	Delta Air Lines
Wittmeyer, John	Delta Air Lines
Earhart, Larry	Executive Jet International
Imrich, Tom	FAA
Williams, Kevin	FAA
Dismukes, Key	NASA Ames
Crittenden, Lucy	NASA Langley
Knox, Charlie	NASA Langley
Stuever, Bob	NASA Langley
Verstynen, Harry	NASA Langley
Wusk, Mike	NASA Langley
Berman, Ben	NTSB
Nyman, Hans	SAS
Ercoline, Bill	Veridian
Barcheski, Richard	United
Gawron, Valerie	Veridian Engineering
Peer, Jeff	Veridian Engineering

Three major changes came from the workshop. First, it was stated that the F/A-18 aircraft would be great fun but is a bad airplane for aerobatic training. Given the funding limitations and the proposed changes to ATP licensing, it was suggested that the evaluation pilots be selected for aerobatic experience. Second, quantitative data from hull loss accidents were required to support airline management training decisions. Third, the Boeing 757 would not be able to duplicate accident scenarios due to safety considerations. Safe initial conditions would be too easy and would not discriminate between training types. The Veridian Variable Stability Learjet was recommended for the evaluation flights.

1.4.5 Identifying Airplane Upset Accidents

It was clear from comments at the workshop that evaluations based on hull-loss accidents would be necessary to convince airline-training managers. Hull loss was defined as: "airplane damage that is substantial and is beyond economic repair. Hull loss also includes events in which: airplane is missing, search for the wreckage has been terminated without it being located, airplane is substantially damaged and inaccessible."[42] The first step in identifying these accidents was to search the online databases listed in Table 7. Accidents identified from this search as both upset and hull-loss accidents are listed in Table 8.

42 http://www.boeing.com/news/techissues/pdf/1997_statsum.pdf

Table 7. Online Databases Searched

Database	Content
Aerospace	Key scientific & technical info supporting aerospace, aeronautics, aircraft, space science
Books in Print	Definitive source for published books
Business & Industry	Multi-industry coverage for facts, figures, key events, from trade & industry
EI Compendex	World's literature of engineering & technology
IAC Industry Express	Coverage of industries, products, overviews
IAC Magazine Index	Coverage of well-known magazines and current affairs, science & technology, etc.
IAC Prompt	Broad coverage of companies, services & applied technologies
INSPEC	Major source worldwide info in electronics, computer systems, physics, engineering, etc.
Jane's Defense & Aerospace	Significant news & developments in aerospace industries & programs
McGraw Hill Publications Online	Coverage for specific industries including aerospace, electronics, etc.
National Technical Information Service (NTIS)	Government sponsored research

Table 8. Commercial Jet, Airplane Upset, Hull Loss Accidents 1959 – 1997

Date	Aircraft	Location	Phase	Description
3/30/67	DC-8	Kenner, LA	Approach	Simulated two-engine out landing[43]
12/27/68	DC-9-15	Sioux City, IA	Climb	Aircraft rolled abruptly and violently to 90 degrees due to icing[44]
7/6/69	B-99	Monroe, GA	Cruise	Descend in near vertical dive due to adverse longitudinal trim conditions[45]
3/31/71	720-047B	Ontario, CA	Approach	Rudder failure during three-engine missed approach during routine proficiency flight[46]
5/30/72	DC-9-14	Fort Worth, TX	Go-around	Extreme roll oscillations due to trailing vortex of DC-10[47]
12/1/74	727-251	Thiells, NY	Climb	Stall at 24,000 feet MSL followed by uncontrolled spiraling descent due to erroneous airspeed and Mach indications as a result of pitot head icing[48]
5/25/79	DC-10-10	Chicago, IL	Climb	During takeoff rotation, left engine, pylon, and portion of leading edge of left wing separated. Aircraft rolled left and pitched down[49]
5/30/84	L-188	Chalkhill, PA	Cruise	Vertical gyro failure[50]
9/6/85	DC-9-14	Milwaukee, WI	Climb	Engine failure after takeoff, roll to right 90o turn, accelerated stall, and crash[51]
2/17/91	DC-9-15	Cleveland, OH	Takeoff	Control problems during takeoff due to minute ice on

43 NTSB SA-397
44 NTSB-AAR-70-20
45 NTSB-AAR-70-18
46 NTSB-AAR-72-18
47 NTSB-AAR-73-3
48 NTSB-AAR-75-B
49 NTSB-AAR-79-17
50 NTSB/AAR-85/04
51 NTSB/AAR-87/01

				wing[52]
3/3/91	737-291	Colorado Springs, CO	Final approach	Jammed rudder[53]
4/5/91	EMB-120	Brunswick, GA	Final approach	Malfunction of left engine propeller control unit allowed propeller blades to go below flight idle position. Rolled to left until wings perpendicular to ground[54]
7/10/91	Beech C99	Birmingham, AL	ILS approach	Encountered weather during ILS approach[55]
2/15/92	DC-8-63	Toledo, OH	Landing	Captain's spatial disorientation and failed attitude director indicator[56]
4/6/93	MD-11	Shemya, AK	Cruise	Inadvertent slat deployment resulting in high "G" pitch oscillations[57]
4/29/93	EMB-120 RT	Pine Bluff, AR	Cruise	In-flight loss of control due to accretion of ice on wing caused stick shaker activation and loss of roll control[58]
9/8/94	737-300	Pittsburgh, PA	Approach	Jammed rudder[59]
10/31/94	ATR 72-212	Roselawn, IN	Cruise	Super-cooled large droplets and super-cooled drizzle droplets increased airplane drag and higher stall speeds[60]
1/17/97	707	Kananga, Zaire	Landing	Right main landing gear collapsed
7/6/97	727-200-247	Albuquerque, NM	Landing	Right main landing gear collapsed[61]
8/7/97	DC8-61F	Miami, FL	Takeoff	Stalled after takeoff
10/10/97	DC-9-32	Nuevo Berlin, Uruguay[62]	Cruise	Thunderstorm

Identifying potential evaluation scenarios for these accidents posed three problems: 1) were they really airplane upsets? 2) were they recoverable? and 3) were they possible in current generation aircraft? These problems were posed to the Boeing member of the review team. He provided direct access to Boeing's accident analysts. The result is provided in the Section 1.3.6.

1.4.6 Identifying Recoverable Airplane Upset Accidents

To identify airplane upset accidents, Boeing limited the list to in-flight loss-of-control accidents. Since all airplane upsets were loss-of-control, all airplane-upset accidents were included in the list. Matches to the definition of airplane upset developed by the Airplane Upset Training Aid Consortium were made after the accident data were received from NTSB. To ensure that the aircraft were recoverable, Boeing performed

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52 NTSB/AAR-91/09
53 NTSB/AAR-92/06
54 NTSB/AAR-92/03
55 NTSB/AAR-92/01
56 NTSB/AAR-92/05
57 NTSB/AAR-93/07
5858 NTSB/AAR-94/02/SUM
[59] NTSB/AAR-99/01
60 NTSB/AAR-96/01
61 NTSB Aviation Accident/Incident Database Report
62 NTSB Aviation Accident/Incident Database Report

extensive simulation and analysis. From this effort, they identified those accidents in which control was compromised (i.e., aircraft was probably not recoverable) and those accidents in which control was available (i.e., aircraft was recoverable). Accidents that could not be definitively placed in either of these categories were grouped as "other" loss-of-control accidents. Finally, to ensure that the accidents were possible in current generation aircraft, Boeing limited the analysis to accidents from 1988 to the last year in which sufficient accident data were available for analysis (i.e., 1997). The resultant list is provided in Table 9a, 9b, 9c, and 9d.

Table 9a. Loss-of-Control Fatal Accidents 1988 - 1998[63] In Which Control Was Compromised (14 Total)

Engine related (7)					**Fatalities**
4/26/89	Barranquilla	CVL	Aerosucre	Lost power after takeoff	7
7/19/89	Sioux City[64]	DC10	United	Uncontained engine failure total loss of hydraulic systems	111
5/26/91	Bangkok	767	Lauda Air	In-flight thrust reverser/stall	223
12/29/91	Taipei, Taiwan[65]	747-200	China Airlines	#3 & #4 engines separated	5
10/4/92	Amsterdam	747	El Al	#3 & #4 engines separated	70
10/22/96	Manta Ecuador[66]	707-323C	Million Air	Loss of power after takeoff	30
10/31/96	Sao Paulo[67]	F-27-MK100	TAM	Thrust reverser deployed in-flight after takeoff 90 ft	98
Systems related (3)					**Fatalities**
6/6/92	Tucuti, Panama[68]	737-204	COPA	Captains ADI	47
4/6/93	Shemya, North Pacific	MD11	China Eastern	Inadvertent slat deployment resulting in high "G" pitch oscillations (PIO)	2
12/20/94	Kano	707	Nigeria	Smoke in cockpit	3
Crew/Operations Related (3)					**Fatalities**
9/15/88	Bahar DAR	737	Ethiopian	Hit birds at liftoff	35
10/2/96	Lima	757	Aeroperu	Plugged static ports	70
3/10/98	Mombassa	707	Air Memphis	Failed to gain altitude following takeoff	6
Structures related (1)					**Fatalities**
3/18/89	Ft. Worth, TX	DC9	Evergreen	Cargo door opened in flight	2

63 Data from Paul Russell (Boeing)
64 NTSB Aviation Accident/Incident Database Report
65 NTSB Aviation Accident/Incident Database Report
66 NTSB Aviation Accident/Incident Database Report
67 NTSB Aviation Accident/Incident Database Report
68 NTSB Aviation Accident/Incident Database Report

Table 9b. Loss-of-Control Fatal Accidents 1988 - 1998[69] Unknown (2 Total)

Unknown (2)					Fatalities
3/3/91	Colorado Springs, CO[70]	737-291*	United	Airplane rolled over into steep dive and loss control during final approach	25
9/8/94	Pittsburgh, PA	737-300	USAir	Airplane rolled over into steep dive and loss control	132

Table 9c. Loss-of-Control Fatal Accidents 1988 - 1998[71] In Which Control Was Available (17 Total)

Engine malfunction plus crew error (4)					Fatalities
1/8/89	East Midlands	737-400	British Midlands	Shutdown wrong engine following engine failure	47
11/24/92	Guilin, China	737	China Southern	Asymmetric thrust, crew failed to recognize roll condition, wrong control input	141
3/31/95	Bucharest, Rom	A310	Tarom	Asymmetric thrust condition plus crew failed to control roll	60
12/3/95	Douala	737	Cameroon	Single engine power loss on short final, initiated go-around, lost control	72
Training/Flight Test (3)					**Fatalities**
3/8/94	Dehli, India	737	Sahara India	Engine out training - outside normal operations (Training)	9
2/4/96	Ascension	DC8	LAC Columbia	Engine out training - outside normal operations (Training)	27
12/22/96	East River Mt[72]	DC8	Airborne Exp.	Test flight training upgrade; outside normal operations	6
Roll Control (3)					**Fatalities**
10/25/88	Juliaca	F2812	AeroPeru	Stall/roll on climb out	12
9/20/90	Marana, AZ[73]	707-321B	Omega Air	Instruments removed	1
2/15/92	Toledo, OH	DC8	Air Transport Int.	Stalled & lost control during missed approach	4
Mode Awareness (2)					**Fatalities**
6/26/88	Mulhouse	A320	Air France	Fly-by demo, crashed into trees	3
4/26/94	Nagoya	A300-600	China Airlines	Pitch-up on go-around	264
Stall (1)					**Fatalities**
11/7/96	Lagos	727	ADC Airlines	Avoiding opposite traffic, accelerated stall, loss control	141
Pilots out of seats (1)					**Fatalities**
3/23/94	Siberia	A310	Aeroflot	Flight crew out of seats; autopilot disconnect with unnoticed control wheel input	75
Failure to maintain altitude (2)					**Fatalities**
3/21/89	Sao Paulo	707	TransBrasil	Failure to arrest rapid descent, landed short	21

69 Data from Paul Russell (Boeing)
70 NTSB Aviation Accident/Incident Database Report
71 Data from Paul Russell (Boeing)
72 NTSB Aviation Accident/Incident Database Report
73 NTSB Aviation Accident/Incident Database Report

2/16/98	Taipei[74]	A-300-B4622R	China Airlines	Crashed during missed approach	203
System malfunction & crew error (1)					**Fatalities**
2/6/96	Puerto Plata[75]	757-200	Birgenair	Stalled - erroneous airspeed & altitude indications; pitot system blocked	189

Table 9d. Loss-of-Control Fatal Accidents 1988 - 1998[76] Other Loss-of-Control (6 Total)

Takeoff Configuration (2)					**Fatalities**
7/23/93	Yinchuan	BAe146	China Northwest	Stalled following no-flap takeoff	55
8/7/97	Miami	DC-8-61	Fine Air	Stalled after takeoff due aft CG	5
Ice/Snow (4)					**Fatalities**
3/10/89	Dryden, Ontario	F-28	Air Ontario	Stalled after takeoff due ice/snow.	24
2/17/91	Cleveland, OH[77]	DC-9-15	Ryan International	Aircraft stalled after takeoff, rolled inverted, and crashed.	2
3/22/92	New York[78]	F-28-MK4000	USAir	Stalled on takeoff - Ice on wings.	27
3/5/93	Macedonia	F100	Pal Air	Stalled following takeoff in snowstorm - No deice	81

1.4.7 Obtain NTSB Data

The accidents listed in Table 9 were sent to NTSB with a request for the time histories of all the aircraft states that were recorded or have been reconstructed recognizing that flight data recorders were sometimes quite inadequate (e.g., too slow sampling rates). This included cockpit control deflections (rudder and throttle in inches, yoke in degrees), surface deflections (in degrees), altitude (feet), velocity (feet per second), linear accelerations (feet per second squared), body axis rates (degrees per second) and accelerations (degrees per second squared), Euler angles (degrees), and autopilot states (engaged or disengaged). The data were requested in an electronic format: ASCII tab- or comma-delimited text format, Mathlab binary format, or Excel spreadsheet format.

After receiving the list, the NTSB requested a prioritization. Accidents with rich data sets were identified as having the highest priority. The second priority was accidents in which control data were available. Since the consortium's definition of an airplane upset excluded training flights, training and flight test accidents were excluded from the list. The last priority was other loss of control accidents.

In most cases, data from foreign carriers were too sparse and foreign accidents were eliminated from consideration.

74 NTSB Aviation Accident/Incident Database Report
75 NTSB Aviation Accident/Incident Database Report
76 Data from Paul Russell (Boeing)
77 NTSB Aviation Accident/Incident Database Report
78 NTSB Aviation Accident/Incident Database Report

1.4.8 Identify Correct Recovery Procedures

Critical to the evaluation of airplane upset training options is defining the correct recovery procedure for each type of aircraft upset. Correct recovery was defined as stabilized flight within the normal flight envelop for transport category aircraft. The procedures are documented in a number of places[79]. The recovery techniques presented in the Airplane Upset Training Aid are presented in Table 10.

Table 10. Airplane Upset Training Aid Correct Recoveries[80]

Nose High Recovery	Nose Low Recovery
Recognize and confirm the situation.	Recognize and confirm the situation.
Disengage autopilot and autothrottle.	Disengage autopilot and autothrottle.
Apply as much as full nose-down elevator.	Recover from stall, if necessary.
Apply appropriate nose-down stabilizer trim.	Roll in the shortest direction to wings level (unload and roll if bank angle is more than 90 degrees).
Reduce thrust (for underwing-mounted engines).	Recover to level flight: • Apply nose-up elevator. • Apply stabilizer trim, if necessary. • Adjust thrust and drag as necessary.
Roll (adjust bank angle) to obtain a nose-down pitch rate.	
Complete the recovery: • When approaching the horizon, roll to wings level. • Check airspeed and adjust thrust. • Establish pitch attitude.	

These were modified (see Table 11 a and b) and expanded (see Table 11 c and d) by American Airlines in their AAMP. Note that AAMP dictates that the first action for any airplane upset is to disengage the autopilot and autothrottle.

Table 11. AAMP Correct Recovery

a. Unusually Nose High Recovery[81]	b. Unusually Nose Low Recovery[82]
Unload with forward yoke pressure toward zero 'G' force	Roll the aircraft in the shortest direction toward the sky pointer
Roll the aircraft toward the nearest horizon – limit bank angle to approximately 60°	With the bank angle in excess of 90°, maintain neutral to forward yoke pressure
Thrust – increase power (in most nose high recoveries)[83]	Coordinated rudder with the roll (top rudder)
As aircraft symbol approaches the horizon, make a coordinated roll out to a wings level slightly nose low attitude	With bank angle less than 60°, increase back pressure on yoke
Check airspeed – adjust thrust and pitch as	Adjust thrust and utilize drag devices as

79 Carbaugh, D. Airplane upset recovery. Annual International Air Safety Seminar. Joint International Meeting FSF, IFA, and IATA "Aviation: Making a Safe System Safer, Capetown, South Africa, November 1998.
80 http://www.boeing.com/commercial/aeromagazine/aero_03/textonly/fo01txt.html
81 American Airlines Advanced Aircraft Maneuvering Program, 1 June 1998, pp. 32 – 33.
82 American Airlines Advanced Aircraft Maneuvering Program, 1 June 1998, pp. 32 – 33.
83 This step is American Airlines unique.

necessary	required. Any speed above or below 'corner speed' (170 KIAS for Learjet) will result in excessive altitude loss. Inverted: UNLOAD AND ROLL FIRST – THEN PULL[84]
c. Wake Turbulence Recovery[85] Apply the appropriate unusual attitude recovery procedure:	d. Low Speed Buffet Recovery[86] Disconnect autopilot and autothrottle
Do not apply any backpressure on yoke at more than 90° of bank. ROLL FIRST – THEN PULL	Unload smoothly – restore laminar flow
High AOA = Coordinated RUDDER	Increase thrust – slowly
<Corner speed (170 KIAS for Learjet) – high lift devices extended[87]	Descend to lower altitude

United Airline's AMP recoveries for nose high and nose low airplane upsets are presented in Table 12.

Table 12. AMP Airplane Recovery Techniques[88]

Nose-high recovery:

1. Recognize the unusual attitude and call out "Attitude."
2. Crosscheck the instuments to verify the upset.
3. Disconnect autopilot and autothrottle if engaged.
4. Initiate the recovery maneuver:
   - "Unload" the airplane
   - Increase bank (not to exceed 60 degrees)
   - Level the wings as the airplane pitch approaches/passes the horizon.
5. Complete the recovery:
   - Adjust pitch and bank to complete the recovery and re-establish the desired airplane attitude.
   - Adjust power only if necessary to aid in the recovery after the initial recovery

Nose-low recovery:

1. Recognize the unusual attitude and call out "Attitude."
2. Crosscheck the instruments to verify the upset.
3. Disconnect autopilot and autothrottle if engaged.
4. Initiate the recovery maneuver:
   - Roll to an upright, wings level attitude.
   - Correct to level flight or a slight climb on the ADI without excessive "G" loading.
5. Complete the recovery:
   - Adjust pitch and bank to complete the recovery and re-establish the desired airplane attitude.

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84 This last step is American Airlines unique.
85 American Airline Advanced Aircraft Maneuvering Program, 1 June 1998, p. 50.
86 American Airline Advanced Aircraft Maneuvering Program, 1 June 1998, p. 63.
87 This step is American Airlines unique.
88 United Airlines Advanced Maneuvers Program Study Guide, April 1999, p. 3-18.

- Adjust power only if necessary to aid in the recovery after the initial recovery.

Delta Airlines' CAST airplane upset recovery procedures are presented in Table 13.

Table 13. CAST Airplane Recovery Process[89]

Nose High Recovery

1) Recognize and Confirm the Situation. Announce, "Recover."
2) Disengage the Autopilot and Autothrottles.

AS NECESSARY:

3) Pitch to unload the aircraft.

IF NECESSARY:

4) Roll to obtain a nose-down pitch rate.
5) Check airspeed and adjust thrust.
6) Level wings approaching the horizon with proper airspeed and trim.

Nose-Low Recovery

1) Recognize and Confirm the Situation. Announce, "Recover."
2) Disengage the Autopilot and Autothrottles.

AS NECESSARY:

3) Pitch to unload the aircraft.

IF NECESSARY:

4) Roll in the shortest direction to wings level; then pull to the horizon.
5) Check airspeed and adjust thrust.
6) Level the aircraft at the horizon with proper airspeed and trim.

None of the above sources included a specific recovery procedure for icing. Members of the review team stated that an icing accident should be included as one of the evaluation scenarios given the prevalence of this type of accident. The FAA's expert in icing accidents, John Dow, provided the correct recovery for icing which he developed in collaboration with Dr. Mike Bragg based on an analysis of several aircraft icing accidents (e.g., see Figure 9) and data from wind tunnel testing. In the accident shown in Figure 9, the crew was climbing and vibration was so severe they could not see the displays. This is a case of an insidious stall accentuated by a slow AOA build up and followed by the rather abrupt aircraft response. The correct recovery for icing without roll anomaly is presented in Table 14 and for icing with roll anomaly in Table 15. Since the Learjet test aircraft (see section 3.1) does not have simulated flap controls, the evaluation pilot's movement to the flap control and verbal "flaps" call will be scored as a control input.

89 Delta Airlines Critical Aircraft Situational Training Home Study Guide, 1 October 1999, p. 5.

Table 14. FAA Icing Recovery No Roll Control Anomaly[90,91,92]

Overpower aileron forces to regain and maintain level flight
Reduce angle of attack by lowering the nose and increasing power
Consider extending the flaps to their first increment if below flaps-extend speed.
But do not retract the flaps if they are extended
Use basic airmanship to maintain airspeed and altitude – in that order

Table 15. FAA Icing Recovery With Roll Control Anomaly[93]

Reduce angle of attack by increasing airspeed or extending wing flaps to the first setting if at or below the flap extension speed (Vfe). If in a turn, roll wings level.
Set appropriate power and monitor airspeed and angle of attack[94]. A controlled descent is a vastly better alternative than an uncontrolled descent
If flaps are extended, do not retract them unless it can be determined that the upper surface of the airfoil is clear of ice. Retracting the flaps will increase the angle of attack at a given airspeed.
Verify that wing ice protection is functioning normally and symmetrically by visual observation of the left and right wing. If not, follow manufacturer's instructions.

90 Manningham, Dan Rolling upsets in severe icing. Business and Commercial Aviation. December 1995.
91 Dow, John Contaminated Stall Recovery, presented at the Icing Conference in Washington DC, February 1999.
92 Hopkins, J. Deadly icing and stall recovery. Flying, September 1999, 58 –59.
93 Dow, J.P., Sr. Roll upset in severe icing. FAA Av News, October 1996.
94 All American Airlines and Delta Airlines aircraft purchased after January 2000 have AOA indicators. Other aircraft do not.

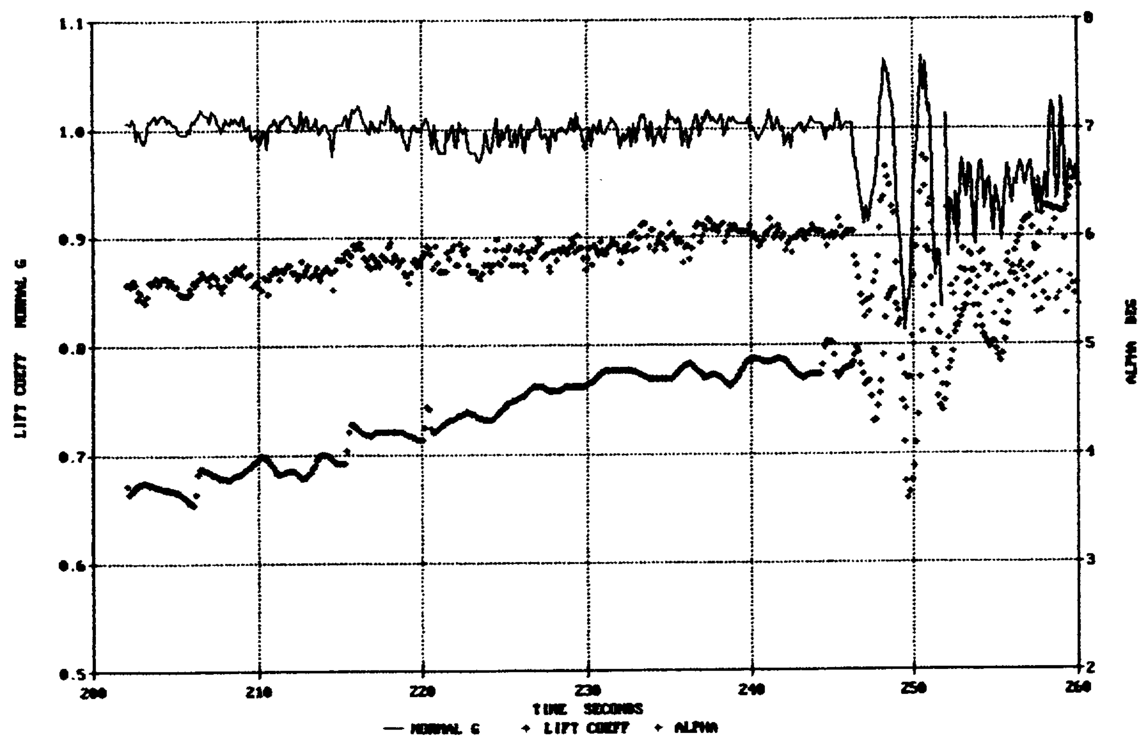

Figure 9. Icing Accident – Advanced Turboprop August 1991

A comparison of the airplane upset recovery procedures is presented in Table 16. For this evaluation, the Airplane Upset Recovery Training Aid recovery procedures were used since these were the consensus of all members of the Airplane Upset Training Aid Consortium. However, there were two exceptions: 1) an icing recovery procedure was developed since several of the candidate evaluation scenarios involved icing and 2) evaluation pilots were required to verbally express the problem to provide data.

Table 16. Comparison of Airplane Upset Recovery Procedures

Element	Training Aid	AAMP	AMP	CAST
Verbally express the problem	No	No	Yes	Yes
Unload in nose high recovery	Yes	Yes	Yes	Yes
Roll in nose high recovery	Yes	Yes	Yes	Yes
Use of thrust	Yes	Yes	Only if necessary after initial recovery	Yes
Roll in nose low recovery	Yes	Yes	Yes	Yes
Emphasis on > 90 degree bank	Yes	Yes	No	No
Address drag	Yes	Yes	No	No
Address corner speed	No	Yes	No	No
Wake turbulence	No	Yes	No	No
Low speed buffet	No	Yes	No	No
Icing	No	No	No	No

1.4.9 Core Team Review

To enhance efficiency, a core team was formed to review the candidate evaluation scenarios. The team consisted of Ben Berman (NTSB), John Cashman (Boeing), Tom Imrich (FAA), John Penney (United), Larry Rockliff (Airbus), and Warren Vanderburgh (American).

The candidate scenarios were developed to reflect all types of loss-of-control accidents (see Figure 4): stall, flight control, icing, and microburst. Note crew disorientation was not included since it could not be reliably induced in the test scenarios. The list of hull-loss accidents between 1959 and 1997 (Table 8) was reviewed again and accidents that met the criteria of being an upset, recoverable, involving either Part 121 or Part 135 aircraft, and possible in current generation aircraft and were not represented in the Boeing list (Table 9) were added. These were limited to microburst, wake turbulence, and system failures other than flight control. Loss-of-control factors reported in incidents (see Figure 5) but not in accidents (and, therefore, not used as a candidate evaluation scenario) were autopilot failure, windshear, aileron failure, yaw damper, and microburst. Upset factors listed in the Airplane Upset Training Aid or the AAMP but not in accident data included: engine failure, gyro, Inertial Navigation System (INS), jammed yoke, GPWS, low speed buffet, and mountain wave.

Candidate scenarios were selected so that there was at least one from five phases of flight (see Figure 6): takeoff, climb, approach, descent, and landing. The list of candidate evaluation scenarios is given in Table 17. Some of the candidate scenarios were difficult or potentially unsafe and were, therefore, not used. Since there was no safe way to evaluate upset recoveries in close proximity to the ground, the takeoff and landing scenarios were flown via a simulated ILS to a "runway-in-the-sky," at a safe altitude, while performing a simulated takeoff/go-around or instrument landing task.

Based on the advice of the core team, eight prototypical accident scenarios were selected to represent a broad range of upset attitude situations. These scenarios are described in section 3.2.

Table 17. Candidate Evaluation Scenarios

Type	Accident	Description	Phase of Flight	Correct Recovery
Stall	10/25/88 Juliaca	Stall/roll	Climb out	Nose high
	2/15/92 Toledo	Stall and lost control	Missed approach	Nose low
	11/7/96 Lagos	Accelerated stall	Cruise	Nose high
	2/6/96 Puerto Plata	Airspeed and altitude error due to blocked pitot system	Cruise	Nose high
	7/23/93 Yinchuan	No flaps	Takeoff	Nose high
	8/7/97 Miami	Aft center of gravity	Takeoff	Nose low
	5/26/91 Bangkok	In-flight thrust reverser	Takeoff	Nose high
Flight control	9/8/94 Pittsburgh	Roll into a steep dive	Approach	Nose low
	11/24/92 Guilin	Asymmetric thrust	Approach	Nose high
	3/23/94 Siberia	Disconnected autopilot	Cruise	Nose low
	7/19/89 Sioux City	Loss of hydraulic system	Approach	Nose high
Icing	3/10/89 Dryden	Ice/snow	Takeoff	Icing
	2/17/91 Cleveland	Rolled inverted	Takeoff	Icing
	3/22/92 New York	Ice on wings	Takeoff	Icing
	3/5/93 Macedonia	Snowstorm	Takeoff	Icing
	10/31/94 Roselawn	Super-cooled large droplets	Climb	Icing
Microburst	10/10/97 Nuevo Berlin[95]	Thunderstorm	Cruise	Nose high
	7/10/91 Birmingham	Thunderstorm	Final approach	Nose low
Wake turbulence	5/30/72 Fort Worth	Extreme roll oscillations	Go-around	Wake turbulence
System failures	5/30/84 Chalkhill	Vertical gyro failure	Cruise	Nose high
	2/15/92 Toledo	Failed attitude director	Landing	Nose high
	4/6/93 Shemya	Pitch oscillations due to slat deployment	Cruise	Nose high
	6/6/92 Tucuti	ADI failure		Nose low
	10/2/96 Lima	Plugged static ports		Nose high

2. EQUIPMENT AND DATA COLLECTION

2.1 TRAINING AND TEST AIRCRAFT

In the original evaluation plan (see Section 1.3.2), the NASA Boeing 757 was proposed as the evaluation aircraft. During the workshop, however, safety-of-flight concerns were raised (see Section 1.3.4). The Veridian Variable Stability Learjet, with its in-flight simulation capability was the next best choice since it could replicate the handling characteristics of commercial aircraft and the flight deck "environment" while

95 NTSB Aviation Accident/Incident Database Report only available

providing a larger safe test envelope (see Figure 10). Note there was no g meter available to the evaluation pilots during the evaluation flights since no current commercial aircraft have a g meter as standard equipment. Based on the accident data (see Table 1), a simplified "generic" aircraft model of a wing-mounted twin-engine, mid-size jet transport was used.

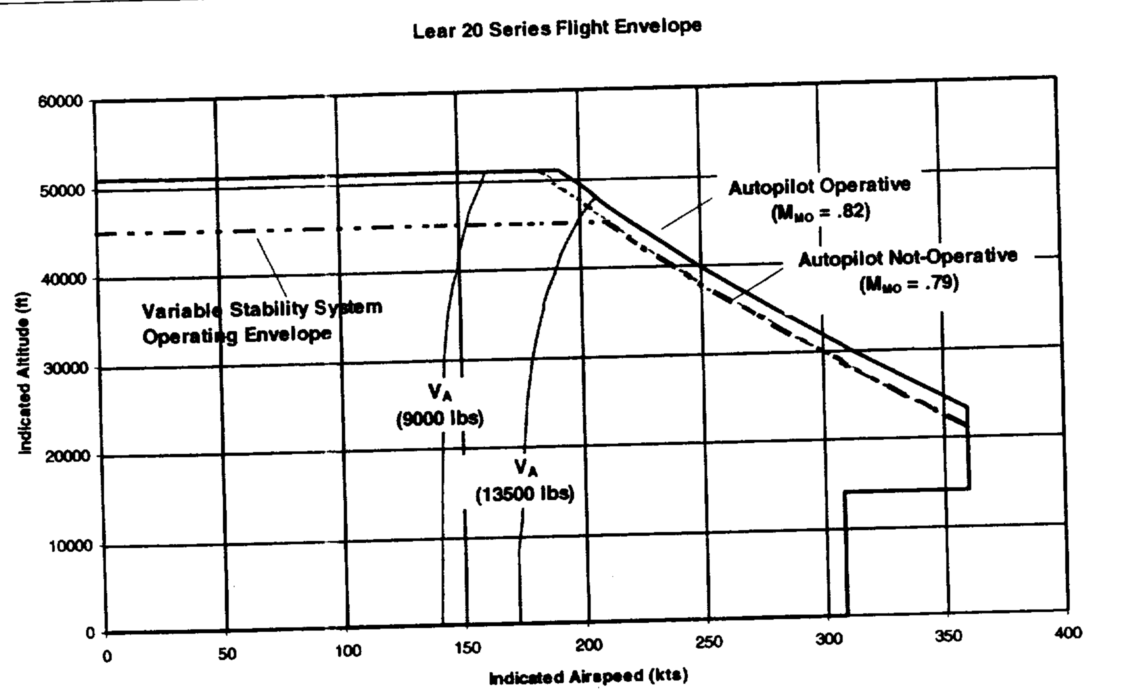

Figure 10. Learjet Flight Envelope

The Veridian In-flight Simulator, Lear 2, was used to provide both the training described in Section 1.2.3 and the evaluation described in Section 4. An in-flight simulator is a *flyable* fixed- or rotary-wing aircraft whose stability and control characteristics and inceptor characteristics can be *easily* varied and changed *while flying*. It is used to simulate the flying qualities of other aircraft and also has been designed to *collect data*. Thus, an in-flight simulator is a "ground simulator that flies," a research test bed aircraft whose characteristics can be easily varied, and a one-of-a-kind operational aircraft that can be used to collect various aircraft, avionics, and/or evaluation pilot performance data.

Lear 2 is a highly modified Learjet 25. Its system design is based on that of the Veridian Learjet 24, which has provided 20 years of reliable service as a stability and control and handling qualities trainer for the U.S. Air Force and U.S. Naval Test Pilot Schools, flying over 700 hours per year. In Learjet 2, Veridian has expanded the Learjet 24's capability and, by choosing a 25 model Learjet, has provided additional cabin space for flight test engineers and test monitors to facilitate their participation in the experiment and data collection. It has a 3-degree of freedom simulation capability.

Converting the aircraft to a variable-stability, in-flight simulator required installing additional control-surface actuators; computers; a right-seat, variable-feel center yoke or stick; a variable-feel side stick; and variable-feel rudder pedals to replace the standard Learjet column, rudder pedals, and pilot interface panels. A normal instrument cluster was retained on the right side but a "flat-panel" display was mounted over this panel, displaying the primary flight information in a pictorial (EFIS) format (see Figure 11). The evaluation pilot's autopilot-disconnect button and normal pitch and roll trim controls are on the yoke, in a standard position. The safety pilot's controls in the left seat, which always reflect the "real Learjet's" control activity, are not masked (see Figure 12). The flight engineer's station is aft of the evaluation pilot's seat and contains a monitor and keyboard (see Figure 13).

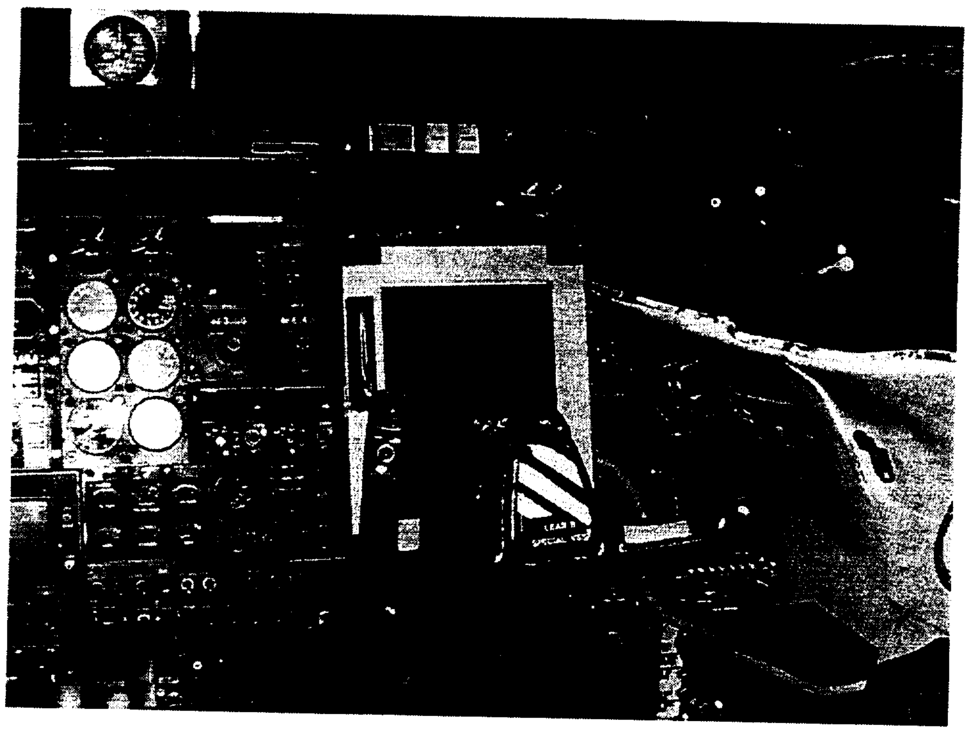

Figure 11. Learjet 2 Right Seat

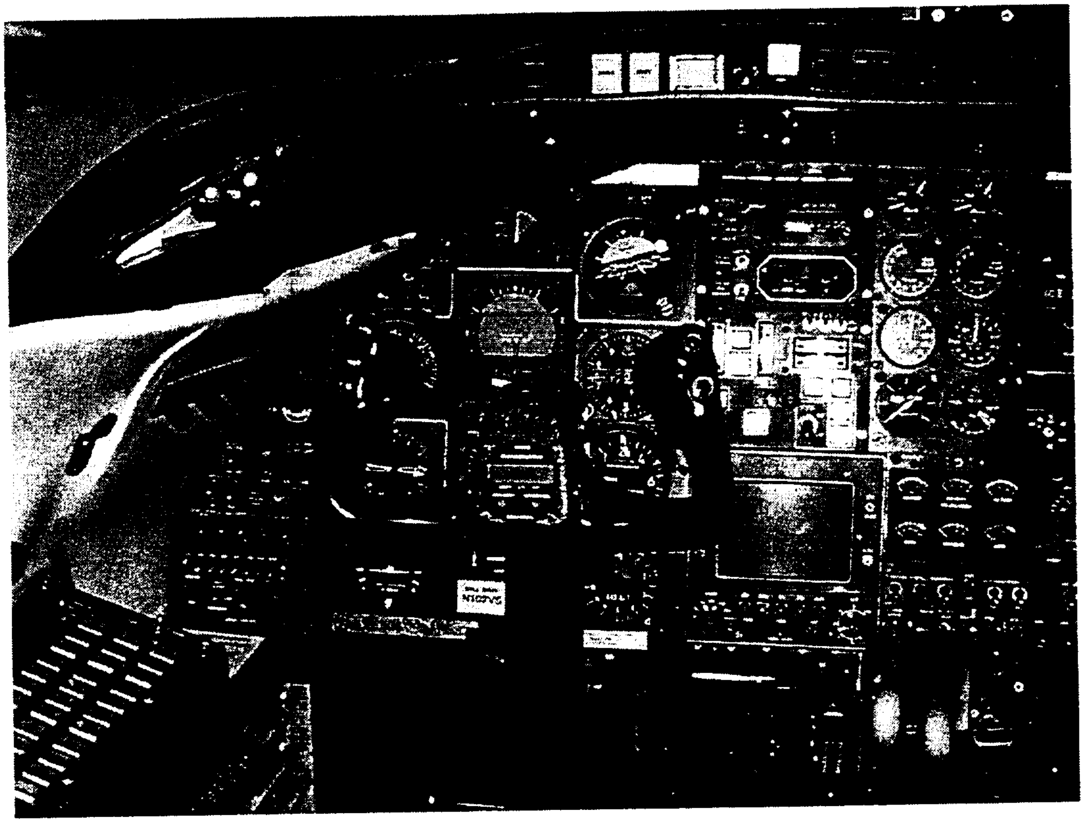

Figure 12. Learjet 2 Left Seat

Figure 13. Learjet 2 Flight Engineer Station with View to Cockpit

The Lear 2 programmable wheel column and rudder were installed at the right-seat (i.e., evaluation) pilot station (see Figure 11). They were programmed to replicate the force and displacement characteristics of a generic airline-type aircraft in pitch and roll. The aircraft response to pitch, roll, and yaw commands replicated the actual forces, motions, and accelerations at the evaluation pilot's seat giving the evaluation pilot the perception of being in a big, long, heavy aircraft with the appropriate responses, field of view, and limitations. Pitch effects due to engine mounting location were also simulated. Other effects such as the correct degree of adverse or proverse yaw, correctly varying dihedral effect (roll due to sideslip), stick shaker and stick pusher, control harmony, etc. were incorporated into the simulation.

Lear 2 had side-by-side pilot stations. The evaluation pilot sat in the right seat (see Figure 11); the safety pilot, in the left seat (see Figure 12). The safety pilot 1) taxis and controls the aircraft until after takeoff, 2) sets up the configuration to be simulated, 3) monitors the aircraft and evaluation pilot state, 4) assumes control of the aircraft in unsafe conditions (e.g., aircraft approaching preplanned limits, automatic safety trips activated, or evaluation pilot inputs grossly incorrect), and 5) performs final approach, landing, and taxi back to the hangar. The evaluation pilot may control the aircraft at all other times. A flight engineer sat aft of the evaluation pilot station (see Figure 13) and controlled all simulation and data collection. The evaluation pilot flew using a standard vision restriction device, a baseball cap like device to obstruct the outside view and simulate IFR flight. The aircraft was flown, by the evaluation pilot, to the initial point of an evaluation maneuver in a series of tasks similar to those performed by the aircrews prior to the eight actual accidents. At a prearranged signal, the flight engineer initiated the evaluation scenario.

Lear 2 was used in its current configuration: no additional displays, controls, or other special equipment were required. There was no masking of safety pilot controls that reflect the actual control surface motions of the Lear jet. The variable stability simulation computer was also programmed to implement simple, conventional, autopilot functions (altitude and heading hold). Recording instrumentation was limited to the flight parameters listed in the next section, out-the-window video, and voice throughout the eight evaluation scenarios. The flight engineer initiated every evaluation scenario and ensured that all data were recorded.

2.2 DATA COLLECTED

Data were collected from 21 August to 22 September 2000. No data were recorded during the training or familiarization flight. The data listed in Table 18 were recorded during each evaluation flight. All data were recorded in one record per evaluation scenario per flight. Audio and video of the flight were also recorded. The measures listed in Table 19 were calculated after each evaluation flight. Datum 1 through 8 (digitally recorded) and the cockpit video were used to calculate the measures listed in Table 19. Datum 9 to 16 (digitally recorded) were used to compare actual to planned time histories. The comparison was used to ensure that Lear 2 remained calibrated, and the scenarios repeatable, throughout the 40 evaluation flights. Additional data were collected for potential future investigations. The complete recording list is presented in Appendix B. Manova were used to analyze measures 4 through 9, χ^2 for

measures 12 to 17. The independent variables for these analyses were group (see Section 4.1) and evaluation scenario (see Table 17). After the flight, the safety pilot completed an instructor evaluation of the evaluation pilot's performance. This evaluation included:

1. Control
2. Anticipation and Situational Awareness
3. Comprehension
4. Overall assessment
5. Successful recovery from upset attitude (YN)

Only two safety pilots participated in the flight test to reduce variability in the evaluations and the scripts. Each safety pilot flew 20 evaluation flights.

Finally, evaluation pilots completed a questionnaire (see Appendix C) at the end of the evaluation flight.

Table 18. Data Collected During Evaluation Flights

Number	Data	Definition
1	Time	Time of day in hours, minutes, seconds and milliseconds.
2	Event marker	Discrete signal triggered when flight engineer initiates evaluation scenario and when safety pilot indicates airplane upset recovery complete. Accompanied by audio tone. 0 = not triggered, 1 = triggered.
3	Autopilot status	1 = engaged, 0 = disengaged. Each scenario begins with the VSS autopilot engaged.
4	Rudder position	Position of the Learjet rudder in degrees.
5	Thrust	Measured Learjet engine thrust in pounds.
6	Wheel column position	Position of the wheel column in inches (pitch) and degrees (roll).
7	Safety trip status	0 = system tripped, 1 = system engaged.
8	Altitude	Altitude in feet.
9	Pitch	Pitch in degrees.
10	Roll	Roll in degrees.
11	Yaw	Yaw in degrees.
12	Rate of climb	Rate of climb in feet per second.
13	N_z	N_z in G.
14	True Airspeed	True airspeed in feet per second.
15	Angle of attack	Angle of attack in degrees.

Table 19. Measures Calculated After Evaluation Flights

Number	Data	Definition
1	Time to first rudder input	Time from start event marker to change in rudder position.
2	Time to first throttle input	Time from start event marker to change in throttle.
3	Time to first wheel column input	Time from start event marker to change in wheel column position.

4	Time to first autopilot input	Time from start event marker to change in autopilot disengaged.
5	Time to first input	Shortest of measures 1 through 4.
6	Time to first correct rudder input	Time from start event marker to change in rudder position in accordance with Table 18 data point 2 to 4.
7	Time to first correct throttle input	Time from start event marker to change in throttle in accordance with Table 18 data point 2 to 5.
8	Time to firstcorrect wheel column input	Time from start event marker to change in wheel column position in accordance with Table 18 data point 2 to 6.
9	Time to recover	Time from start event marker to end event marker.
10	Altitude loss	Altitude at start time minus altitude at wings level.
11	Procedure used to recover the aircraft	Video of evaluation pilot's actions from start event marker to end event marker.
12	Number of correct actions in recovery	Sum of the number of correct actions executed in the correct sequence determined from the video & Tables 10 through 14
13	Number of safety trips tripped (per flight)	Number of the safety trips tripped summed across each evaluation pilot (including safety pilot trips).
14	Number of correct first inputs	Number of correct first inputs summed across each of the five groups.
15	Number of first correct pitch inputs	Number of first correct pitch inputs summed across each of the five groups.
16	Number of first correct roll inputs	Number of first correct roll inputs summed across each of the five groups.
17	Number of first correct throttle inputs	Number of first correct throttle inputs summed across each of the five groups.

3. EXPERIMENT

The experiment was a comparison of the airplane upset recovery performance of five groups of pilots. The pilots differed in the type of airplane upset recovery training they had received, if any. These groups are described in section 3.1. The airplane upsets were eight evaluation scenarios selected from fatal airplane upset accidents that occurred within the last ten years. These are described in detail in section 3.2 and as well as the complete set of selection criteria. To ensure that these eight scenarios matched the timelines of events in the actual accidents, three calibrations flight were flown (see section 3.3.1). To ensure that all eight scenarios were realistic, two validation flights were flown with airplane-upset experts from the airlines, FAA, and NTSB (see section 3.3.2). Pilots were recruited through the ALPA web site and magazine as well as through extensive use of professional societies (see section 3.3.3). Given the diversity of backgrounds, pilots in all five groups were trained in the procedures for the in-flight simulator. Pilots from four of the groups received a dedicated flight to familiarize themselves with the aircraft displays, controls, and operating procedures. These familiarization flights are described in section 3.3.4. Pilots from the group which received airplane upset training using the in-flight simulator familiarized themselves with the aircraft in the first part of their training flight. Pilots from all five groups flew one evaluation flight in which they were tasked with recovering from the eight scenarios. The order of the scenarios was counterbalanced across pilots. In addition one scenario was repeated at the end of the flight to assess the effect of surprise on recovery performance. These evaluation flights and the following debriefs are described in section 3.3.5. Extensive data were collected during this experiment including questionnaire

responses, safety pilot ratings, videotape, and digital recording of performance data. Procedures for reducing these data for analysis are detailed in section 3.3.6.

3.1 GROUP DESCRIPTIONS

The evaluation was a between-subjects design with five groups. Each group was composed of eight, non-military, airline pilots in their probationary year. Non-military pilots were selected since trends suggest that in the future these pilots will make up the majority of new hires in the airlines. Further, there are differences in aircraft accident data between military and nonmilitary pilots. For example, a comparison of general aviation crashes was made between military pilots (205) and nonmilitary pilots (32,807) over a sixteen-year period (1983 to 1998). Military pilots were more likely to have advanced licenses and higher total flight times than civilian pilots[96]. Based on airplane upset recovery data from a military transport, it was expected that eight evaluation pilots per group were required for 95% statistical power and 5% type-one error. The selection criteria were based on minimizing variability among evaluation pilots while reflecting the population of future pilots. Pilot recruitment is described in section 3.3. Pilots' backgrounds are described in section 5.1. Note pilots came from 27 different airlines. There was no attempt to balance airlines between groups since all pilots met the same hiring requirements. However, since groups 3 and 4 required current airplane upset training these groups were populated from the three of the 27 airlines that provide this training (i.e., American, Delta, and Untied).

3.1.1 Group 1

The first group, "No aero/no upset," was made up of pilots in their probationary year at an airline. The pilots did not have any aerobatic flight experience. This group was the baseline against which all other groups were compared. It was also the group that represents those Part 121 carriers that have so far opted not to include training in recovery from upsets and unusual attitudes in their initial and recurrent flight training (RFT).

3.1.2 Group 2

The second group, "Aero/no upset," was made up of pilots in their probationary year at the airline but these pilots did have relatively recent aerobatic experience. Aerobatic experience was defined as at least six-hours of training completing Aileron Roll, Barrel Roll, Chandelle, Cloverleaf, Cuban Eight, Immelmann, Lazy Eight, Loop, Split S, and Stall Turn maneuvers or experience performing in airshows or stunts in an aircraft with an FAA aerobatic waiver. This group represented the effects of a change to the ATP licensing that has been proposed by several airlines and the ATA, specifically that aerobatic experience such as that described above be mandatory as part of the ATP.

3.1.3 Group 3

The third group, "No aero/upset," was made up of pilots in their probationary year at the airline and who have received airline provided airplane-upset training in both ground school and in the ground simulator. These pilots did not have any aerobatics

[96] Gillis, L.G., Li, G., and Baker, S.P. General aviation crashes involving military personnel as pilots. Aviation, Space, and Environmental Medicine, 2001, 72(11), 1001 – 1005.

training or experience. This group represented those airline operators that include Airplane Upset Recovery Training as part of the line-oriented flight training (LOFT). This training consisted of two to eight hours of briefings as well as two hours of simulator time for each pilot in accordance with FAR Section 121.409. In this case, the training included a complete flight crew performing normal and abnormal procedures in flight segments appropriate for the operator. Prior to beginning Airplane Upset Recovery Training, the operator was expected to verify the ground simulator's capability to support this type of training.[97]

Additional required criteria were:

1. Does the airline have a formal upset training academic program?
2. Does the airline include upset training in transition training?
3. Is upset training repeated during each recurrent cycle?
4. Does the airline use its own or leased simulators?
5. Do airline instructors receive specific training to ensure the upset training is valid and accurate?[98]

All five criteria were met in the two groups who received airplane upset training from the airlines.

3.1.4 Group 4

The fourth group, "Aero/upset," received the same training as Group 3 but in addition had aerobatic flight experience as Group 2. This group represented the training offered by SAS and Cathy Pacific Airlines both of whom provide ground school, simulator, and in-flight aerobatics training.

3.1.5 Group 5

The fifth group, "In-flight," was made up of pilots who received in-flight airplane upset training using an instrumented in-flight simulator, the Veridian Variable Stability Learjet (see section 1.2.3). These pilots had not received airline-upset training at their respective airlines. The Veridian In-flight Upset Recovery Training was modified from the standard training described in Appendix A for this evaluation. Specifically, the aerobatic flight was eliminated so that this group would not have any aerobatic experience as defined in Group 2. Further to minimize the time evaluation pilots were scheduled to be in Buffalo, ground school was given in the morning of day 1, followed by an in-flight simulation flight in the afternoon. The evaluation flight was given the morning of day 2. This is in contrast to groups 2, 3, and 4, in which the interval between training and testing was much longer, ranging from 7 days to 14 years. This confound will be considered in the Discussion section.

3.2 EVALUATION SCENARIOS

From the candidate evaluation scenarios listed in Table 15, eight accidents upon which the evaluation scenarios were based were selected. These are described in greater detail with their associated recovery procedures in the following sections. The recovery

97 Dornheim, M.A. Loss of control under scrutiny. Aviation Week and Space Technology, 27 April 1998.

98 Criteria developed by Larry Rockliff (Airbus)

procedures varied between evaluation scenarios. For example, ATC needs to be informed when the recovery or the upset cause a deviation from assigned altitude or airspeed or they need to request a different altitude, airspeed, or heading. The urgency to report this is different between the scenarios so the call to ATC would be accordingly higher or lower on the list or even not on the list. Scripts for the safety pilot and flight engineer for each evaluation scenario are presented in Appendix D. Note that evaluation pilots were instructed to recover using whatever procedures they felt were appropriate. They were neither encouraged nor precluded from using the procedures of their own airline.

3.2.1 7/10/91 Birmingham

This accident occurred during an instrument landing approach in a Beech C99. The aircraft encountered a thunderstorm cell of at least a VIP 3 level on final approach. The cell contained "very strong vertical air shafts and associated turbulence."[99] The storm placed the aircraft in an airplane upset from which the aircrews were unable to recover. There was no flight data recorder on board. The only data available were the radar data for the instrument approach and crash. The 45° left bank coupled with nose high attitude and severe turbulence (as recalled by the captain who survived the accident) were used as the initial condition for this evaluation scenario. The autopilot was not engaged. Note that the Lear was programmed such that full forward yoke input would not reduce the pitch attitude. Based on this accident, the NTSB recommended, "recurrent training and proficiency programs for instrument-rated pilots include techniques for recognizing and recovering from unusual attitudes" (p. 74). The correct recovery was:

1. Initially requires full aileron input to fight uncommanded roll.
2. Full down elevator with trim to keep the AOA within limits.
3. Use bank angle as required to control flight path.
4. Airspeed should maintain safe margin above accelerated stall speed.
5. Airspeed should not exceed maneuver speed.

Omission of one parameter may or may not affect recovery depending on the parameter and the scenario. If an airplane is about to stall, not reducing AOA will affect the outcome. Failure to maintain airspeed below maneuver speed alone will not however.

3.2.2 2/15/92 Toledo

This accident involved loss of control of a Douglas DC-8-63 after executing a second missed approach. The NTSB determined that the probable cause was "the failure of the flightcrew to properly recognize or recover in a timely manner from the unusual aircraft attitude that resulted from the captain's apparent spatial disorientation, resulting from physiological factors and/or a failed attitude director indicator" (p. 60).[100] The evaluation scenario was flown as if by the first officer in the accident who assumed control from an incapacitated (vertigoed) Captain. The timeline is presented in Figure 14. The scenario began with the VSS computer placing the Lear 2 in the nose low and left wing down attitude representative of the Toledo accident. The evaluation pilot was

99 NTSB/AAR-92/01
100 NTSB AAR-92-05 - Air Transport International, Inc., Flight 805 Douglas DC-8-63, N794AL Loss of Control and Crash Swanton, Ohio February 15, 1992.

then expected/directed to take control and recover the aircraft to level flight. The autopilot was not engaged. The correct recovery was:

1. Announce problem (e.g. "attitude").
2. Crosscheck instruments.
3. Disconnect (Autopilot, etc.).
4. Aggressively roll right to approximately wings level.
5. Use rudder to enhance roll rate.
6. Retard power to remain near corner speed.
7. Full aft column and nose-up trim to 2.5 g pull up.
8. Maintain climb until 1500 AGL.

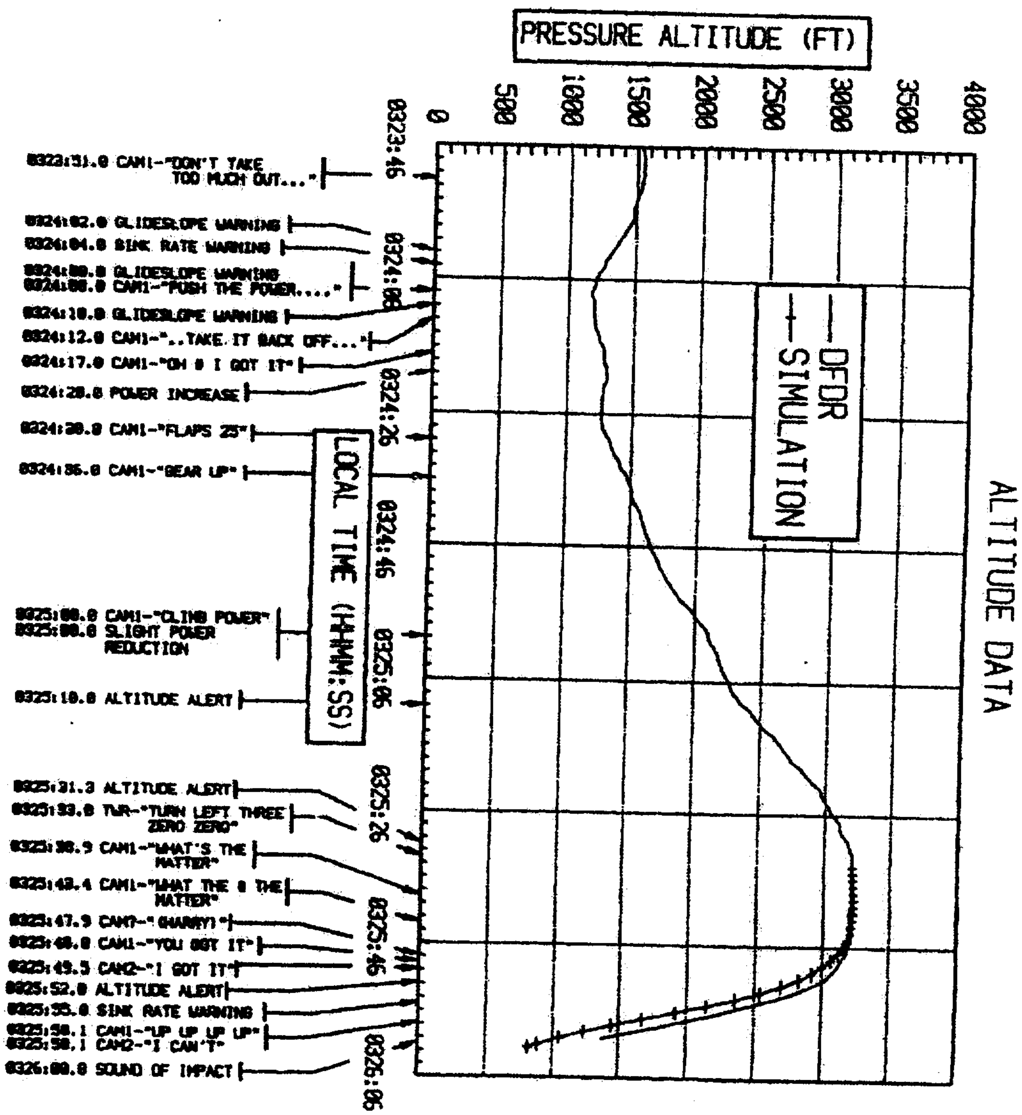

Figure 14. 2/15/92 Toledo Accident Data Timeline

3.2.3 4/6/93 Shemya

This accident occurred during cruise due to an inadvertent deployment of the leading edge wing slats.[101] "The captain's attempt to recover from the slat extension, given the reduced longitudinal stability and the associated light control force characteristics of the MD-11 in cruise flight, led to several violent pitch oscillations. Contributing to the violence of the pitch oscillation was the lack of specific MD-11 pilot training in recovery from high altitude upsets" (p. v).[102] The evaluation scenario started with the initial pitching moment due to simulated slat deployment. The Lear 2 simulated the reduced stability and light control force characteristics representative of the MD-11 at high altitude cruise emphasizing the sensitive pitch response. The evaluation pilot attempted to maintain altitude without over controlling the aircraft in pitch. The autopilot was engaged. The correct recovery was:

1. Announce problem (e.g. "autopilot's acting strange").
2. Disconnect button (i.e., depress master disconnect button).
3. Recognize PIO tendency.
4. Back out of pitch control loop to avoid coupling.
5. Use low pitch control gains.
6. Use low frequency pitch inputs.
7. Use lag compensation in pitch.
8. Don't chase altitude.
9. Trim to near 1 g flight.
10. Investigate source of problem.
11. Cautiously release master disconnect button.
12. Inform ATC of problem/altitude deviation.
13. Descend to lower altitude.

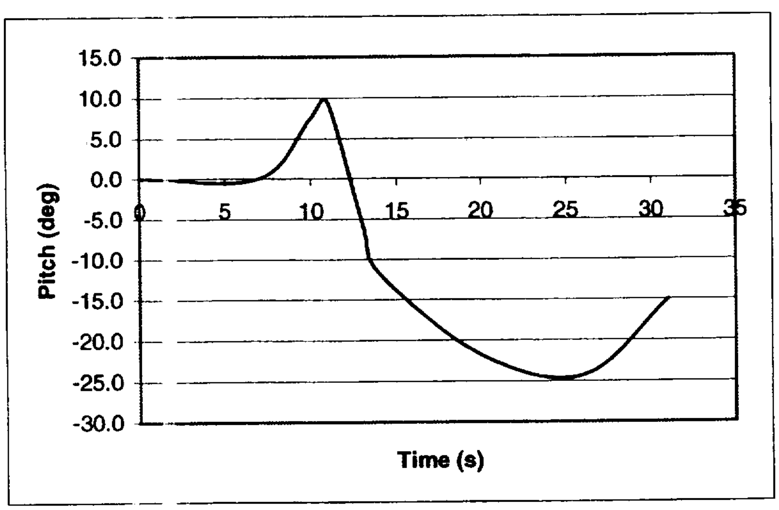

Figure 15. 4/6/93 Shemya Accident Data Timeline

101 NTSB/AAR-93/07 – Inadvertent in-flight slate deployment China Eastern Airlines Flight 583 McDonnell Douglas MD-11, B-2171 950 Nautical Miles South of Shemya, Alaska April 6, 1993
102 NTSB/AAR-93/07 – Inadvertent in-flight slate deployment China Eastern Airlines Flight 583 McDonnell Douglas MD-11, B-2171 950 Nautical Miles South of Shemya, Alaska April 6, 1993

3.2.4 4/26/94 Nagoya

The Aircraft Accident Investigation Commission of the Ministry of France investigated this upset accident involving an A-300 aircraft. They summarized the accident in the following words: "While the aircraft was making an ILS approach to Runway 34 of Nagoya Airport, under manual control by the [first officer] F/O, the F/O inadvertently activated the GO lever, which changed the FD (Flight Director) to GO AROUND mode and caused a thrust increase. This made the aircraft deviate above its normal glide path. The [autopilots] APs were subsequently engaged, with GO AROUND mode still engaged. Under these conditions the F/O continued pushing the control wheel in accordance with the [Captain] CAP's instructions. As a result of this, the THS (Horizontal Stabilizer) moved to its full nose-up position and caused an abnormal out-of-trim situation. The crew continued approach, unaware of the abnormal situation. The AOA increased, the Alpha Floor function was activated and the pitch angle increased. It is considered that, at this time, the CAP (who had now taken the controls), judged that landing would be difficult and opted for go-around. The aircraft began to climb steeply with a high pitch angle attitude. The CAP and the F/O did not carry out an effective recovery operation, and the aircraft stalled and crashed" (section 4).[103] The aircraft state data from the horizontal stabilizer in its full nose-up position to impact were derived from the report. Since this was a foreign accident, the NTSB did not retain flight data recorder records. Therefore, the scenario was generated from information in the report from the Japanese government. To enhance the safety of the test, the Lear 2 simulation included an ILS approach at altitude using on-board sensor data. While the evaluation pilot was flying the glideslope, the autopilot trimmed the aircraft to a full nose up configuration. At go-around, the autopilot was released providing the evaluation pilot with extensive trim forces. This provided the same aircraft response as the actual accident but was not related to mode confusion as in the original accident – although the recovery procedure was the same. The autopilot was not engaged. The correct recovery was:

1. Announce problem.
2. Disconnect autopilot (i.e., depress master button).
3. Use full nose down column.
4. Roll the aircraft to reduce the vertical component of the lift vector and prevent the aircraft from climbing too steeply. Actively adjust bank angle to control flight path angle.
5. Airspeed should be kept low to reduce the gs and the consequent bank angle required to maintain level flightpath.
6. Call for emergency nose down trim.
7. Investigate source of problem.
8. Cautiously release master disconnect button.
9. Inform ATC of problem/altitude deviation/inability to hold heading.

103 Aircraft Accident Investigation Report 96-5 by Hiroshi Sogame and Peter Ladkin.

3.2.5 7/2/94 Charlotte

This accident occurred during approach due to a microburst. The NTSB stated that among the probable causes were: "2) the flightcrew's failure to recognize a windshear situation in a timely manner; 3) the flightcrew's failure to establish and maintain the proper airplane attitude and thrust setting necessary to escape the windshear" (page 120)[104]. The evaluation scenario started with an initial right roll and continued for the forty seconds in Figure 16. The autopilot was not engaged. The scenario consisted of a simulated ILS approach at altitude with artificial injected turbulence and simulated high sink rate at some point above MDA. The correct recovery was:

1. Maximum thrust.
2. Disconnect autopilot.
3. Leave gear and flaps unchanged.
4. Rotate to 15° pitch attitude.
5. Accept low airspeed.
6. Use near stick shaker angle of attack.
7. Do not lower nose in an attempt to increase airspeed.

104 NTSB AAR-95/03 – Flight into terrain during missed approach USAir Flight 1016, DC-9-31, N954VJ Charlotte/Douglas International Airport Charlotte, North Carolina July 2, 1994

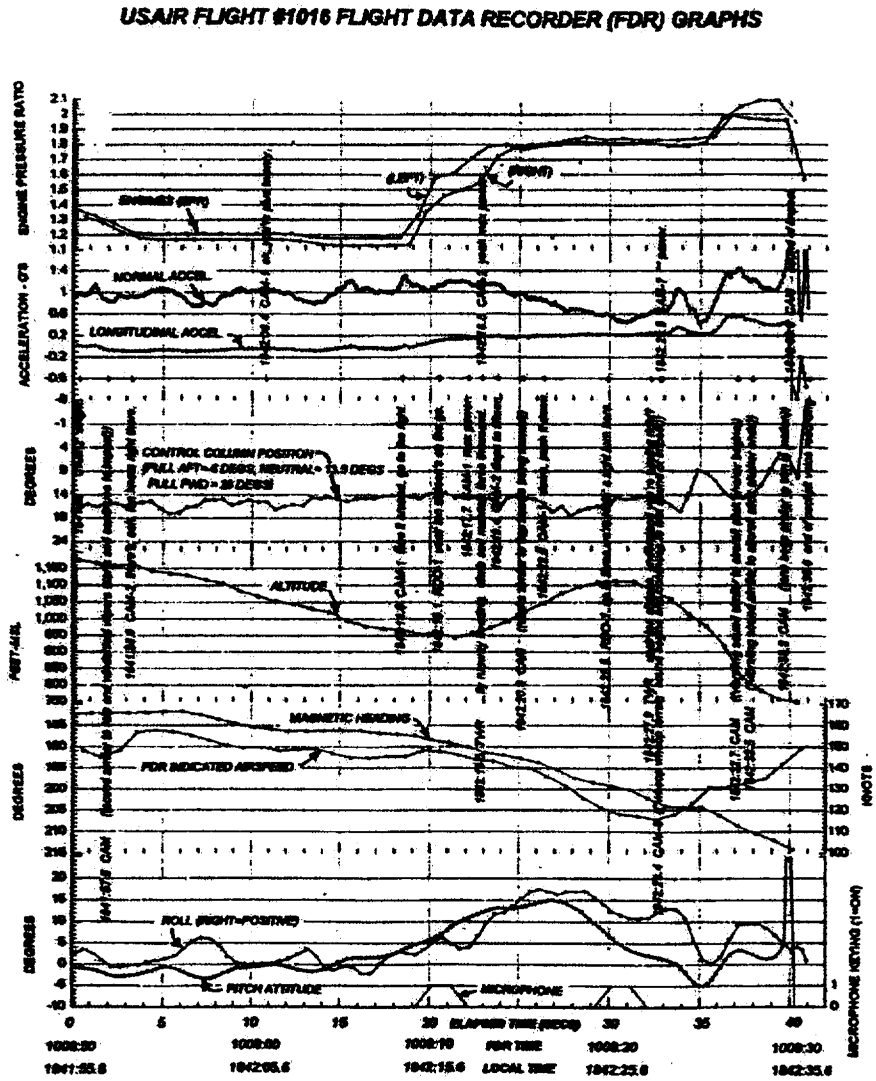

Figure 16. 7/2/94 Charlotte Data Timeline

3.2.6 9/8/94 Pittsburgh

This airplane upset accident occurred during initial approach. The aircraft experienced a hard-over rudder that caused it to yaw and then roll uncontrollably to the left. In spite of full aileron input the pilots could not control the uncommanded roll. The NTSB recommended that Boeing 737 flight crews be provided "with initial and recurrent flight simulator training in the "Uncommanded Yaw or Roll" and "Jammed or Restricted Rudder" procedures in Boeing's 737 Operations Manual. The training should demonstrate the inability to control the airplane at some speeds and configurations using

the roll controls (the crossover airspeed phenomenon)"[105]. The evaluation scenario began at a speed less than the aileron/rudder crossover speed with a small uncommanded roll due to simulated wake turbulence, followed by an uncommanded yaw and roll to the left due to a "hard-over" rudder. The autopilot was not engaged. The correct recovery procedure was:

1. Attitude crosscheck.
2. Disconnect (Autopilot, etc., etc.).
3. Attempt to use opposite rudder and aileron.
4. Unload pitch axis – push, don't pull.
5. "Unload" pitch if more roll rate is required or if bank will exceed 70-90 degrees.
6. Use split thrust to roll to wings level.[106]
7. Total thrust should be adjusted in consideration of both crossover speed and corner speed.
8. Return to starting altitude/heading.
9. Inform ATC.
10. Troubleshoot rudder hardover.

105 NTSB AAR-99/01 – Uncontrolled Descent and Collision with Terrain. USAir Flight 427, Boeing 737-300, N513AU, Near Aliquippa, Pennsylvania September 8, 1994, p. 297.

[106] Boeing and FAA identified correct response for rudder hardover.

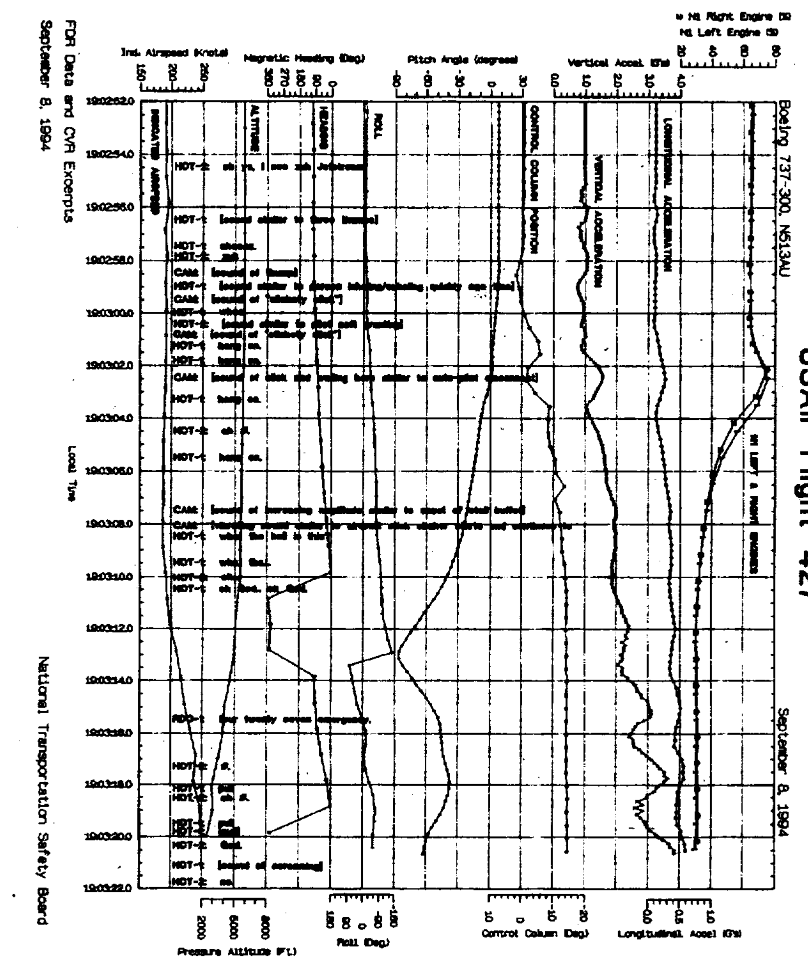

Figure 17. 9/8/94 Pittsburgh Accident Data Timeline[107]

3.2.7 10/31/94 Roselawn

This accident occurred during a descent to an altitude of 8,000 feet at which time an uncommanded roll, due to the buildup of ice on the wings, occurred. The NTSB identified flightcrew training for unusual attitudes as a safety issue in this accident. The NTSB recommendation was: "Amend the Federal Aviation Regulations to require operators to provide standardized training that adequately addresses the recovery from unusual events, including extreme flight attitudes in large, transport category airplanes" (p. 214). The evaluation scenario started with an initial uncommanded roll, followed by simulated aileron snatch that occurred as a function of angle-of-attack, simulating the effect of a wing-ice induced stall. The autopilot was not engaged. The correct recovery was:

1. Use full opposite aileron, rudder, and possibly split thrust to roll to wings level.

107 NTSB AAR-99/01 – Uncontrolled Descent and Collision with Terrain. USAir Flight 427, Boeing 737-300, N513AU, Near Aliquippa, Pennsylvania September 8, 1994, p. 5.

2. Angle of attack should be reduced:
   - When wheel snatches.
   - To improve aileron roll effectiveness.
   - To prevent a stalled wing.
   - Anytime bank will exceed 70°-90°.
3. Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed.
4. Flaps should be set back to 20°.
5. Return to starting altitude/heading.
6. Inform ATC.
7. Troubleshoot deice system.

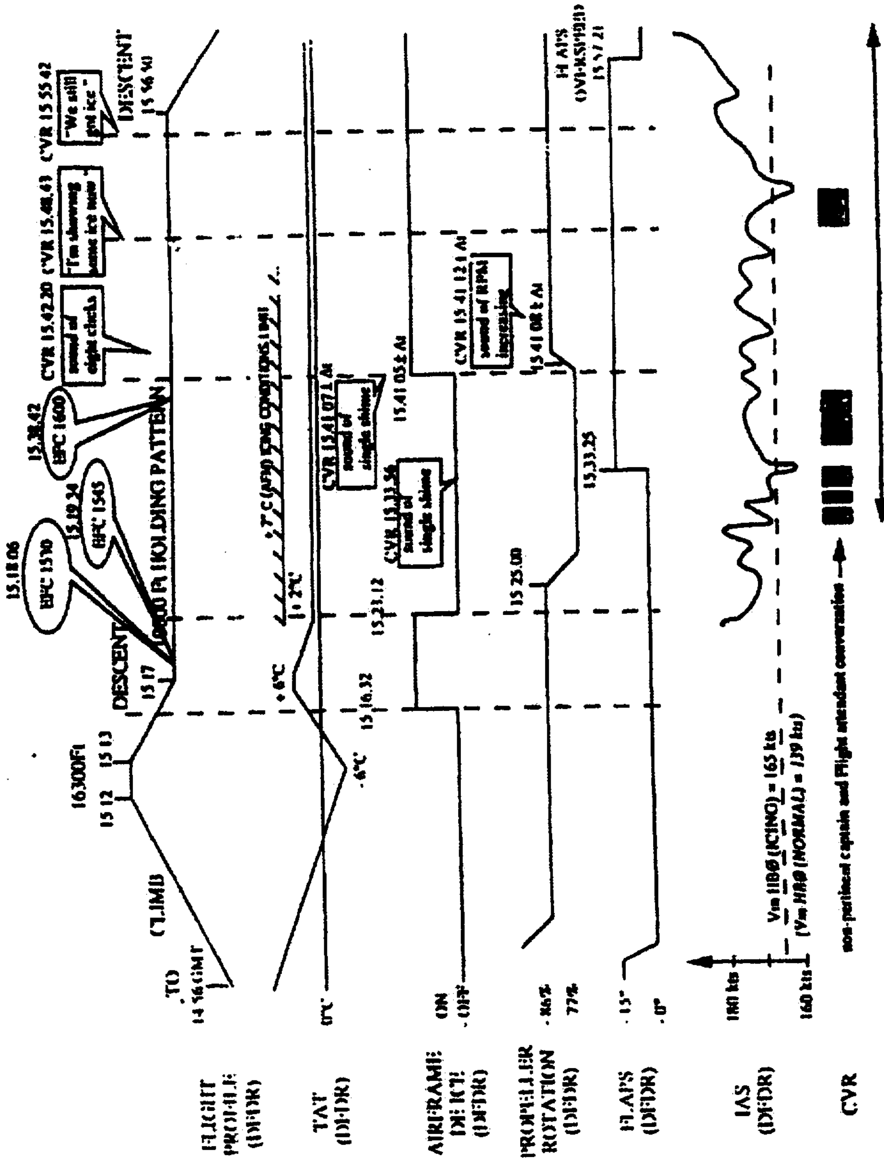

Figure 18. 10/31/94 Roselawn Accident Data Timeline

3.2.8 1/9/97 Detroit

This accident involved a rapid descent after an uncommanded roll excursion. The accident was an example of icing resulting in an asymmetric lift. This was a simplified version of the Roselawn accident since it did not include the aileron snatch.[108] The NTSB recommended "With the National Aeronautics and Space Administration and other interested aviation organizations, organize and implement an industry-wide training effort to educate manufacturers, operators, and pilots of air carrier and general aviation turbopropeller-driven airplanes regarding the hazards of thin, possibly imperceptible, rough ice accumulations, the importance of activating the leading edge deicing boots as soon as the airplane enters icing conditions (for those airplanes in which ice bridging is not a concern), and the importance of maintaining minimum airspeeds in icing conditions" (p. 182). The autopilot was not engaged. The correct recovery is:

1. Angle of attack should be reduced:
   - To improve aileron roll effectiveness.
   - To prevent a stalled wing.
   - Anytime bank angle will exceed 70°-90°.
2. Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed.
3. Flaps may be set to 20°, speed permitting.
4. Return to starting altitude/heading.
5. Inform ATC.
6. Troubleshoot deice system.

108 NTSB AAR-98/04 – In-flight icing encounter and uncontrolled collision with terrain COMAIR Flight 3272 Embraer EMB-120RT, N254CD, Monroe Michigan January 9, 1997

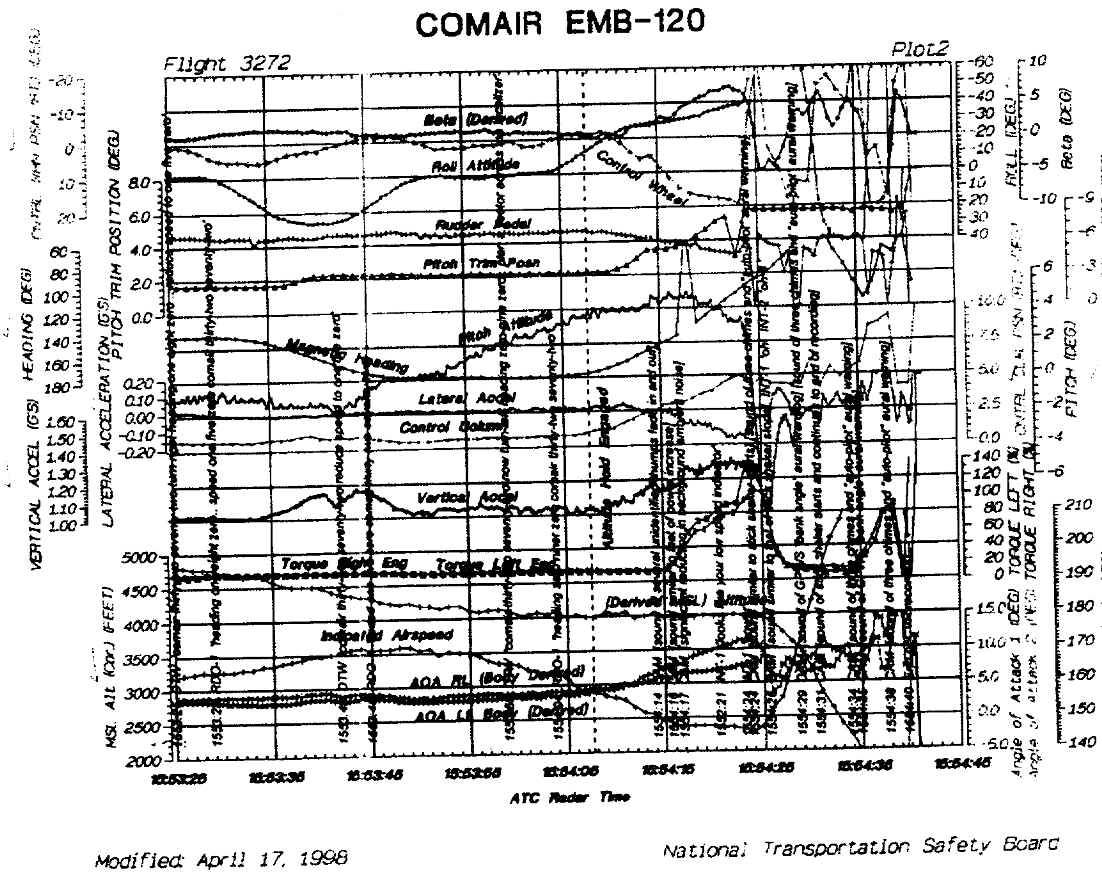

Figure 19. 1/9/97 Detroit Accident Data Timeline

3.2.9 Summary

The accidents were selected to meet a number of criteria. Table 20 provides a tally of these accidents against those criteria.

Table 20. Accidents by Criteria

Criterion	*Birmingham 7/10/91*	*Toledo 2/15/92*	*Shemya 4/6/93*	*Nagoya 4/26/94*	*Charlotte 7/2/94*	*Pittsburgh 9/8/94*	*Roselawn 10/31/94*	*Detroit 1/9/97*
Hull loss / fatalities	Yes/13	Yes/4	No/2	Yes/264	Yes/37	Yes/132	Yes/68	Yes/29
Upset[109]	> 10° pitch down	> 45° roll	> 10° pitch down	> 10° pitch down	Inappropriate airspeed	> 10° pitch down > 45° roll	> 45° roll	> 45° roll

[109] An airplane upset is defined as: pitch attitude greater than 25° nose up, pitch attitude greater than 10° nose down, bank angle greater than 45°, or within the above parameters but flying at airspeeds inappropriate for the conditions (Airplane Upset Recovery Training Aid)

Recoverable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Current aircraft	Beech C99	DC-8-63	MD-11	A-300-600	DC-9-31	B737-300	ATR 72-212	EMB-120RT
Type								
Stall								
Flight control		Sink rate	Slats	Autopilot		Rudder		
Icing							√	√
Microburst	√				√			
Phase								
Climb		√						
Cruise			√					
Descent							√	
Approach	√			√	√	√		√

3.3 PROCEDURES

Procedures for the calibration, validation, familiarization, and evaluation flights as well as for recruiting evaluation pilots and for data reduction are presented in the following sections.

3.3.1 Procedures for the Calibration Flights

After the eight evaluation scenarios were programmed in the Lear 2 and ground checked using Lear 2 as a ground simulator, three flights were conducted with two Veridian safety pilots and the flight test engineer who eventually flew all of the evaluation flights. The purpose of these flights was to test and modify the evaluation scenarios, aircraft dynamics, and recording system. These flights were conducted during the weeks of 7 and 14 August 2000.

3.3.2 Procedures for the Validation Flights

Following these three calibration flights, two validation flights were flown using an NTSB investigator, airline-training supervisor, and FAA national resource specialist to ensure the acceptability of the evaluation scenarios. These validation flights were key for industry representatives to get a sampling of the testing first hand. It offered the chance to screen out any potential "bugs" in the program or conditions that might later risk a challenge to the results. These flights were accomplished on 16 and 18 August 2000. Comments included: "good demo," "excellent one," "very challenging," and "interesting to figure out." Suggested changes came in the form of tighter compliance to typical airline procedures, slight modification of the generic airplane model, and setting a slightly slower airspeed for one scenario. All evaluators agreed that the scenarios were appropriately implemented and provided realistic cues.

3.3.3 Procedures for Recruiting Evaluation Pilots

For the evaluation flights, evaluation pilots were recruited from U.S. passenger airlines. One hundred and five pilots who fit the selection criteria (less than one year in a passenger airline, never flown for the military) either called the 800 number or emailed the principal investigator. They flew for 27 different airlines (see Table 21). The first forty were scheduled and the remaining 65 were placed on the alternate list. Of these 65,

38 were No aero/no upset, 13 No aero/upset, 10 Aero/no upset, and 4 Aero/upset. Twenty-seven of the alternates were called due to scheduling problems experienced with the original forty pilots. Partial information was obtained from twelve additional volunteers. Subsequent follow up with these volunteers was ceased after the last evaluation pilot completed the evaluation flight. There were also 44 pilots who volunteered but did not fit the time criteria (had flown over one year in fact up to 23 years with their current airline). Another five were not currently flying for an airline with an additional 4 not flying for a passenger airline (e.g., DHL or Emery Worldwide). Nine additional volunteers met both the time and passenger airline criteria but had flown or were flying for the military. The total number of pilots volunteering for this study was 179.

Table 21. Airlines of 100 Volunteers Who Fit Selection Criteria

Air Wisconsin	Comair	Piedmont
Allegheny	Continental	Ryan
America West	Continental Express	Sky Way
American	Delta	Sky West
American Eagle	Mesa	Trans States Airlines
ASA	Mesaba	TWA
ATA	Midway	United
Atlantic Coast	Midwest Express	US Airways
Big Sky	Northwest	US Airways Express

As part of the recruitment process, evaluation pilots were given a flyer (presented in Appendix E) and a poster (presented in Appendix F). When the evaluation pilots arrived at the hotel in Buffalo, they were given a welcome package consisting of a welcome letter, the informed consent form Parts 1 and 2 (presented in Appendix G), a description of the Veridian In-flight Simulator, and resumes of the two safety pilots who flew the evaluation flights.

3.3.4 Procedures for the Familiarization Flights

The evaluation pilots in Groups 1 through 4 flew to Buffalo, spent the night at a local hotel, and then flew a familiarization (~0.7 hours) and an evaluation flight (~1.0 hour) the following day. The evaluation pilots were briefed in pairs starting at 7 am. The briefing was in accordance with the guide in Appendix H. They then selected which evaluation pilot would fly first. The familiarization flight equalized the familiarity of these four groups with the fifth group that received in-flight airplane upset training in the same aircraft. The familiarization flight script is given in Table 22. For the familiarization flights, the safety pilot did all vectoring and setup. The evaluation pilot did turns up to 45 deg bank, accelerations and decelerations, changes of aircraft configuration (PA-CR), practiced ILS "in the sky" approaches to a minimum altitude, and got thoroughly familiar with the displays and controls. In addition, during the flight, the evaluation pilots learned to engage and disengage VSS; received cockpit familiarization; reviewed safety and emergency procedures; but did not see any upsets or uncommanded inputs. The flight took approximately 45 minutes. The evaluation pilots in Groups 1 to 4 flew 21 August to 14 September and 25 and 26 September. The evaluation pilots in

Group 5 flew 18 to 22 September. All evaluation pilots were briefed in pairs with the exception of the last two who were briefed separately due to scheduling problems.

Table 22. Familiarization Flight Script

IFR flight plan < BUF - ROC - IAG - BUF > (if IMC)
Safety Pilot takes off
At 2500', in a stabilized climb, Evaluation pilot takes control
Fly ATC vectors to ROC and perform ILS or SP vectors to "ILS in-the-sky"
Fly ATC vectors to IAG and perform ILS with missed approach and one turn in
Holding followed by ILS touch-and-go at IAG or SP vectors as above
Return to BUF for ILS low approach followed by Safety Pilot full stop

The evaluation pilots in Group 5, "In-flight," received four hours of ground school and a training flight and then spent the night at a local hotel. These eight evaluation pilots flew an evaluation flight the next day. The ground school consisted of review of 117 slides divided into 5 modules: overview, causes of upsets, aerodynamics, upset recovery, and a Learjet briefing. The material reviewed in the ground school is listed in Appendix A. The training flight consisted of 11 exercises. In each exercise the degree of the effect being demonstrated (e.g., location of the center of gravity in exercise one) could be varied depending on the skill, knowledge, and confidence of the student. These settings varied between 1 (easy) and 10 (difficult). The instructor selected the exercise and its difficulty level using a keypad attached to his kneepad (see Figure 20). In exercise one, the center of gravity was moved from the middle of the aircraft forward (easy) and aft (more difficult). The effects of two aft positions on aircraft handling qualities were demonstrated. In exercise two, a Dutch Roll was demonstrated; in three, a Pilot-Induced Oscillation (PIO) prone aircraft; in four, g was varied in both nose high and nose low positions. The purpose of exercise four was to develop g awareness. Exercise five simulated entry into wake turbulence. There were three entry points: at the leading edge, through the center, and at the trailing edge of the wake vortex. Exercise six was practice recovering from a nose up trim runaway; exercise seven from an aileron failure; eight from a rudder failure; nine from a nose down trim runaway; and ten from a complete hydraulic system failure. The eleventh exercise was making three Instrument Landing System (ILS) "in-the-sky" approaches using the raw ILS data presented on the flat panel located directed in front of the evaluation pilot. This last exercise matched that included in the familiarization flights flown by the other 32 evaluation pilots.

Figure 20. Instructor's Keypad

3.3.5 Procedures for the Evaluation Flights

Prior to each evaluation flight, the evaluation pilot received a briefing reiterating the purpose and nature of the test as stated in Appendix I. Three people were on board during each evaluation flight: evaluation pilot, safety pilot, and flight engineer. The two evaluation pilots attended the preflight briefing together (to reduce variability in the briefings). Then one flew while the other waited. When the first pilot returned, he or she was kept separate from the second pilot. Specifically placed in a separate room for the debrief and upon completion taken immediately to the airport to go home. The second pilot in the meantime was taken to the airplane to fly. Each evaluation flight included 8 evaluation scenarios. The order of the evaluation scenarios was counterbalanced (see Table 23). If there was a malfunction or a safety trip during an evaluation scenario, that scenario was repeated at the end of the flight. This occurred in two cases. In both cases the airplane-upset event had not yet occurred when a safety trip was activated. In addition, after completing the eight evaluation scenarios, the flight test engineer repeated one evaluation scenario to insert an element of surprise and potential confusion.

The calibration flights were used to determine if there would be sufficient flight time for one of these "surprise" scenarios.

Table 23. Order of Testing

Order	Evaluation Scenario
1	8, 1, 7, 2, 6, 3, 5, 4
2	1, 2, 8, 3, 7, 4, 6, 5
3	2, 3, 1, 4, 8, 5, 7, 6
4	3, 4, 2, 5, 1, 6, 8, 7
5	4, 5, 3, 6, 2, 7, 1, 8
6	5, 6, 4, 7, 3, 8, 2, 1
7	6, 7, 5, 8, 4, 1, 3, 2
8	7, 8, 6, 1, 5, 2, 4, 3
9	1, 7, 2, 6, 3, 5, 4, 8
10	2, 8, 3, 7, 4, 6, 5, 1
11	3, 1, 4, 8, 5, 7, 6, 2
12	4, 2, 5, 1, 6, 8, 7, 3
13	5, 3, 6, 2, 7, 1, 8, 4
14	6, 4, 7, 3, 8, 2, 1, 5
15	5, 8, 4, 1, 3, 2, 6, 7
16	8, 6, 1, 5, 2, 4, 3, 7
17	7, 2, 6, 3, 5, 4, 8, 1
18	8, 3, 7, 4, 6, 5, 1, 2
19	1, 4, 8, 5, 7, 6, 2, 3
20	2, 5, 1, 6, 8, 7, 3, 4
21	3, 6, 2, 7, 1, 8, 4, 5
22	4, 7, 3, 8, 2, 1, 5, 6
23	8, 4, 1, 3, 2, 6, 7, 5
24	6, 1, 5, 2, 4, 3, 8, 7
25	2, 6, 3, 5, 4, 8, 1, 7
26	3, 7, 4, 6, 5, 1, 2, 8
27	4, 8, 5, 7, 6, 2, 3, 1
28	5, 1, 6, 8, 7, 3, 4, 2
29	6, 2, 7, 1, 8, 4, 5, 3
30	7, 3, 8, 2, 1, 5, 6, 4
31	4, 1, 3, 2, 6, 7, 5, 8
32	5, 2, 4, 3, 8, 7, 6, 1
33	6, 3, 5, 4, 8, 1, 7, 2
34	7, 4, 6, 5, 1, 2, 8, 3
35	8, 5, 7, 6, 2, 3, 1, 4
36	1, 6, 8, 7, 3, 4, 2, 5
37	2, 7, 1, 8, 4, 5, 3, 6
38	3, 8, 2, 1, 5, 6, 4, 7
39	1, 3, 2, 6, 7, 5, 8, 4
40	5, 2, 4, 3, 8, 7, 6, 1

After completing the flight the evaluation pilot completed the questionnaire presented in Appendix C. Meanwhile the safety pilot, who remained blind to the evaluation pilot's training background (except for the in-flight simulation training), completed the following rating scale of the pilot's ability to recover from all eight evaluation scenarios as well as the surprise scenario.

Control – the subject's ability to keep the aircraft within the required parameters (airspeed, altitude, bank angle, angle of attack, and g):

Large excursions	No large excursions	Precision
1	3	5

Anticipation and Situational Awareness – the subject's ability to control the vehicle in a timely manner:

Large corrections	No large corrections	Very few inputs
1	3	5

Comprehension – the subject's ability to learn to recover across the entire flight:

No change over flight	Only slight improvement	Improves throughout flight
1	3	5

Overall assessment – the evaluator's rating of the subject's piloting ability:

Requires constant monitoring	Occasionally uncertain	Instills confidence
1	3	5

3.3.6 Procedures for the Data Reduction

Data came from four sources: 1) participants' post-flight questionnaire ratings, 2) safety pilots' rating scale, 3) video tape, and 4) digital recording of performance data. Data from the first two sources were entered manually into Excel spreadsheets for subsequent data analysis. Videotapes were reviewed and event times and spoken commands transcribed into an Excel spreadsheet for subsequent concatenation with the digital data. The digital data, in time history format, were evaluated against pre-determined recovery procedures for each configuration/departure. The pre-determined recovery procedures for each scenario are shown in Table 24. Mathlab scripts were developed to automate the data reduction process and make it consistent and repeatable (see Appendix J).

The beginning of each maneuver is characterized by a specific condition (e.g., a bank angle of 5°). The time when this condition is reached is defined as the event start time. The Mathlab script determined the event start time and the time that the evaluation pilot made the anticipated inputs (e.g., definitive forward stick input). For all the values used, see Table 24. Note that the time to autopilot disconnect was measured from the scenario start event to the initial autopilot disconnect button press, i.e., the autopilot disconnect button did not have to be held. The flight test engineer reviewed the time histories to determine if the times were accurate or caused by spurious data. If the times were accurate, they were written on a copy of the time histories and transcribed to an Excel spreadsheet. The time histories were then printed for later reference. The spreadsheet was programmed to calculate the delta time from event start time to the

anticipated evaluation pilot input. These times were then concatenated to the video data for subsequent statistical analysis. A scenario was repeated on Flight 1505, Record 14, Pilot 1027, Toledo because of a safety trip. The EP recovered. A scenario was repeated on Flight 1510 after flying almost the entire Charlotte maneuver before the display locked up. The lock-up occurred before the windshear event so the maneuver was repeated. There were no performance data reduced for the first occurrence of either Toledo or Charlotte scenario since the airplane upset event had not yet occurred.

Table 24. Values of Parameters Used to Determine Performance in Evaluation Scenarios

Scenario	Data Point	Units	Definition	Threshold	Variables
Birmingham	Event Start	Time (sec)	Rapid roll left	When phi < - 5.0 deg	Time, phi
	1	Time (sec)	Announce problem		Time, voice transcript
	2	Time (sec)	1st definitive aileron input	fas > 10 lb	Time, fas
	3	Time (sec)	1st definitive rudder input	frp > 10 lb	Time, frp
	4	Time (sec)	1st definitive elevator input	fes < -10 lb	Time, fes
	5	Time (sec)	1st trim input	When trim > trim at EST + 5.0 deg	Time, stab_trim
	6	Phi (deg)	Adjust bank angle to control flight path angle (gamma)		Time, phi, gamma
	7	Airspeed (KIAS), Vertical Acceleration (G)	Airspeed kept above accelerated stall speed but below Va		Time, vi, [(nz)*(-1)]
Toledo	Event Start	Time (sec)	phi = -5 deg		Time, phi
	1	Time (sec)	Announce problem		Time, voice transcript
	2	Time (sec)	1st autopilot disconnect		Time, ap_eng, ap_disc, sys_eng
	3	Time (sec)	1st definitive aileron input	fas > 10 lb	Time, fas
	4	Time (sec)	1st definitive rudder input	frp > 10 lb	Time, frp
	5	Time (sec)	1st definitive throttle input	Thrust delta > 100 lb	Time, thrust (total thrust)
	6	Airspeed (KIAS)	Near corner speed		Time, vi
	7	Time (sec)	1st definitive elevator input	fes > 10 lb	Time, fes
	8	Time (sec)	1st trim input		Time, stab_trim
	9	Vertical Acceleration (g)	Max vertical acceleration	Max Acceleration during the event	Time, [(nz)*(-1)]
	10	Altitude (ft)	Altitude lost	Altitude at EST	Time, h_cf

Scenario	Data Point	Units	Definition	Threshold	Variables
				minus the min altitude during the event.	
Shemya	Event Start	Time (sec)	Autopilot Lateral Stick Input	dasm > 0.3	Time, dasm
	1	Time (sec)	Announce Problem		Time, voice transcript
	2	Time (sec)	Depress A/P disconnect		Time, ap_eng
	3	Time (sec)	Definitive aileron input	fas>10 lb	Time, fas
	4	Time (sec)	Definitive elevator input	fes>10 lb	Time, fes
	5	des (deg), fes (lb)	Low pitch control gains and frequency		Time, des, fes
	6	Altitude (ft)	Don't chase altitude		h_cf, display11
	7	Time (sec)	1st trim input	destrimc>.001	Time, stab_trim, destrimc
	8	Time (sec)	Investigate Source of Problem		Time, voice transcript
	9	Time (sec)	Time to 2nd press of A/P disconnect button		Time, ap_eng
	10	Nz (g)	Max evaluation pilot station Nz in recovery		Time, nzp
	11	Nz (g)	Min evaluation pilot station Nz in recovery		Time, nzp
Nagoya	Event Start	Time (sec)			event_m
	1	Time (sec)	Announce problem		Time, voice transcript
	2	Time (sec)	Depress master disconnect		Time, ap_disc
	3	Time (sec)	1st definitive correct elevator input (nose down)	fes < -10 lb	Time, fes
	4	des (in)	Wheel Full Forward	des = -3.0	Time, des
	5	Time (sec)	1st definitive aileron input	fas > +/-10 lb	Time, fas
	6	A/S (KIAS)	Airspeed Loss	EST airspeed – min airspeed	Time, vi (or display02)
	7	Phi (deg), gamma (deg)	Adjust bank angle to control flight path	See "Method of Recovery" Column of Digital Data	Time, phi, gamma
	8	Time (sec)	Call for emergency trim		Time, voice transcript
	9	Time (sec)	1st emergency trim input		Time, stab_trim
	10	Time (sec)	Investigate source of problem		Time, voice transcript
	11	Time (sec)	Inform ATC of problem/altitude deviation/ inability to		Time, voice transcript

Scenario	Data Point	Units	Definition	Threshold	Variables
			hold heading		
Pittsburgh	Event Start	Time (sec)	Start rudder hardover	Yaw rate < -2.0 deg/sec	Time, dr
	1	Time (sec)	Announce problem		Time, voice transcript
	3	Time (sec)	Depress master disconnect		Time, ap_disc
	4	Time (sec)	1st definitive rudder input	frp > 10 lb	Time, frp
	5	Time (sec)	1st definitive aileron input	fas > 10 lb	Time, fas
	6	Time (sec)	1st definitive correct elevator input (push, don't pull)	fes < -15 lb	Time, fes
	7	Phi (deg)	Unload pitch axis if more roll rate required or bank angle will exceed 70-90 deg	Phi at first correct elevator input	Time, fes, p, phi
	8	fes (lb)	Unload pitch axis if more roll rate required or bank angle will exceed 70-90 deg	fes at phi = -70 deg	Time, fes, p, phi
	9	Time (sec)	1st definitive throttle split	thrust_l – thrust_r > 200 lb	Time, thrust_l, thrust_r
	10	Altitude (ft)	Altitude lost	EST alt – min alt	Time, h_cf
	11	Time (sec)	Inform ATC of problem/altitude deviation		Time, voice transcript
	12	Time (sec)	Troubleshoot rudder hardover		Time, voice transcript
Charlotte	Event Start	Time (sec)	Airspeed Roll-Off	Airspeed drop > 9.5 kts/sec	Time, display02
	1	Time (sec)	Announce Problem		Time, voice transcript
	2	Time (sec)	1st definitive thrust input	thrust delta>200	Time, thrust
	3	Time (sec)	Autopilot Disconnect		Time, ap_eng
	4	Time (sec)	Leave Flaps/Gear unchanged		Time, voice transcript
	5	Time (sec)	1st definitive elevator input	fes>10 lb	Time, fes
	6	Time (sec)	Rotate to 15 deg pitch attitude	Theta>15 deg	Time, theta
	7	Airspeed (KIAS)	Accept low airspeed	Accelerate more than 25 knots	display02
	8	rms on stickshaker	% time on stick shaker		Time, shaker
	9	Time (sec)	Don't lower nose for airspeed		display02, fes, theta
	10	Time (sec)	Achieve definitive positive rate of climb	hdot>500 ft/min	Time, h_dot_cf

Scenario	Data Point	Units	Definition	Threshold	Variables
	11	Display14 (radalt)	Altitude Lost in recovery		display14
Roselawn	Event Start	Time (sec)	Aileron snatch	Delta Aileron > 10 deg coupled with lateral stick in opposite direction of bank angle	Time, da, phi, fas
	1	Time (sec)	Announce problem		Time, voice transcript
	2	Time (sec)	1st definitive aileron input	fas > +/-10 lb after EST	Time, fas
	3	Time (sec)	1st definitive rudder input	frp > +/-10 lb after EST	Time, frp
	4	Time (sec)	1st definitive throttle split	Delta (thrust left - thrust right) > 100 lb)	Time, thrust_l, thrust_r
	5	Time (sec)	Definitive Alpha Reducing elevator inputs (nose down)	fes > 10 lb with a reduction in AOA	Time, fes
			Wheel snatches		Time, fes, des
			Improve aileron roll effectiveness		Time, fes, p
			Prevent stalled wing		Time, fes, p
			Bank angle will exceed 70-90 deg		Time, fes, phi
	6	Time (sec)	1st definitive correct throttle input	Total thrust > thrust at EST + 200 lb	Time, thrust
	7	Airspeed (KIAS)	Max airspeed	Max airspeed during the event	Time, vi
	8	Time (sec)	Flaps set back to 20 deg		Time, voice transcript
	9	Altitude (ft)	Altitude lost	Altitude at EST minus the min altitude during the event.	Time, h_cf
	10	Time (sec)	Inform ATC of problem/altitude deviation		Time, voice transcript
	11	Time (sec)	Troubleshoot de-ice system		Time, voice transcript
Detroit	Event Start	Time (sec)	Rapid roll rate	Roll rate > +/- 5.0 deg	Time, p
	1	Time (sec)	Announce problem		Time, voice transcript
	2	Time (sec)	1st definitive aileron input	fas > +/-10 lb after EST	Time, fas
	3	Time (sec)	1st definitive rudder input	frp > +/-10 lb after EST	Time, frp
	4	Time (sec)	1st definitive throttle split	Delta (thrust left - thrust right > 100	Time, thrust_l, thrust_r

Scenario	Data Point	Units	Definition	Threshold	Variables
				lb)	
	5	Time (sec)	Definitive elevator inputs (nose down)	(fes > 10 lb)	Time, fes
			Improve aileron roll effectiveness		Time, fes, p
			Prevent stalled wing		Time, fes, p
			Bank angle will exceed 70-90 deg		Time, fes, phi
	6	Time (sec)	1st definitive correct throttle input	Total thrust > thrust at EST + 200 lb	Time, thrust
	7	Airspeed (KIAS)	Max airspeed	Max airspeed during the event	Time, vi
	8	Time (sec)	Flaps set back to 20 deg		Time, voice transcript
	9	Altitude (ft)	Altitude lost	Altitude at EST minus the min altitude during the event.	Time, h_cf
	10	Time (sec)	Inform ATC of problem/altitude deviation		Time, voice transcript
	11	Time (sec)	Troubleshoot de-ice system		Time, voice transcript

Standard descriptive statistics were used to validate the data.

4. OPERATING HAZARD ANALYSIS

The variable stability system safety trip logic on Lear 2 automatically disengages the system if selected parameters exceed preset levels. The system may be manually disengaged by push buttons located on each pilot's control as well as buttons located on the safety pilot's throttle and glare shield. Inputs to the automatic safety trips consist of the following groups of parameters:

- Excessive surface and feel system rates
- Excessive surface hinge moments
- Excessive linear accelerations
- Excessive angle of attack
- Attitude gyro flag
- Yaw damper/autopilot engage
- Configuration control system
- Hydraulic fluid level
- Vertical tail load

Each input with the exception of the manual disengage signal is controlled by circuits that allow separate adjustment of the trip level and a time delay. The time delay permits momentary transients to exceed the preset trip levels without disengagement of the system, resulting in a "nuisance trip." Table 25 is a list of each safety trip signal and

the level at which a trip occurs. These safety trip levels well exceed the normal transport category flight envelope and thus do not limit the evaluation pilot inputs during the recoveries from the evaluation scenarios. The Learjet safety trips are designed to protect the Learjet from exceeding structural limits as well. While these limits are outside of normal transport-category flight envelope, no attempt was made to simulate the modeled aircraft structural envelope. In all cases the safety pilot was able to discern whether the correct input was made in the cases before the safety trip was activated.

Table 25. Learjet Safety Trips

PARAMETER	TRIP LEVEL
Manual	—
CCS Error	Discrete
Attitude Gyro Flag	Discrete
Yaw Damper/Auto Pilot	Discrete
Low Hydraulic Oil Level	Discrete
Surface Servo Commanded Rates	
– Elevator	100 deg/sec
– Aileron	200 deg/sec
– Rudder	200 deg/sec
Surface Servo Hinge Moment	
– Elevator	114 lbs
– Aileron	45 lbs
– Rudder	208 lbs
Normal Acceleration	+2.8 g (max) +0.15 g (min)
Lateral Acceleration	± 0.3 g
Angle of Attack	+10° (max) -5° (min)
Feel System Accelerations	Representing hardover
Vertical Tail Load	Structural protection
Maximum Sideslip Limit	± 15 degrees

The safety trip system incorporates an annunciator to identify, by TAG code (see Table 26), the parameter that disengaged the system including the manual trip. An audio alarm and flashing light activate when a safety trip occurs, as well as control reverting, instantaneously, to the safety pilot

Table 26. Safety Trip Codes

Code	Description
ED	Elevator Surface Rate
AD	Aileron Surface Rate
DD	Rudder Surface Rate
* BD	Elevator Differential Pressure #2 (STAB TRIM) (ST-1)
EA	Normal Acceleration
DA	Lateral Acceleration
AA	Maximum Angle of Attack
* EB	Elevator Differential Pressure #1
* AB	Aileron Differential Pressure
* DB	Rudder Differential Pressure
EF	Elevator Feel Acceleration
AF	Aileron Feel Acceleration
DF	Rudder Feel Acceleration
CE	Configuration Control System
CF	Attitude Gyro Flag
C2	Yaw Damper or Autopilot Engaged
C1	Low Hydraulic Fluid or Standby FBW Disengage
BA	(TRM) Negative Limits (ST-2)
BB	Top Rolling Moment $+\frac{5\ TRM}{7900}$ (ST-3)
BF	B Limit ± 15 degrees (ST-4)
FF	Manual Safety Trip

NOTES: 1) *Indicates pressure transducer failure

2) On occasion, surface rate and differential pressure limits are exceeded concurrently. The tag codes are E9, A9, and D9 for the elevator, aileron, and rudder, respectively.

Engage logic is incorporated which permits either pilot to engage the variable stability system. The major controls are the following:

- Feel Engage
- Pressurize
- Surface Engage
- Backup Fly By Wire Select
- Surface Select (Elevator, Aileron and Rudder)

The engage logic is interconnected with the safety trip preventing engagement under unfavorable circumstances. An automatic or manual safety trip will disengage the feel system and surface servos in addition to removing hydraulic pressure from all the

servos. When the backup Fly-by-Wire mode is selected, the safety trip system is deactivated.

If the variable stability system (VSS) is automatically shut off, it is essential that the safety pilot recognize that he must immediately assume control of the airplane. This is particularly important when close to the ground or close to another aircraft. To help the evaluation pilot recognize when the system is dumped, a flashing red light labeled "SAFETY TRIP" has been provided on the left side of the VSS engage panel. A non-mutable audio signal resembling "beep, beep, beep" is also heard in all headsets and cabin speakers. The safety trip signal responsible for disengaging the VSS is identified by a code displayed above the safety trip light.

In the event of incapacitation of the safety pilot or certain control cable failures, the aircraft can be flown by the evaluation pilot as a nearly normal Learjet using the VSS in the "Fly-By-Wire" mode. All basic Learjet systems (gear, flaps, spoilers, brakes, etc.) are available. The handling characteristics are those of the basic aircraft with yaw damper on. All safety trips are removed from the circuit and no feedback loops are used except for yaw damping.

The control characteristics in this mode are optimized for approach and landing. As a result the aircraft may seem sensitive at higher speeds. Longitudinal trim reverts to normal aircraft trim but VSS trim is used for rudder and ailerons. All trim switch locations remain the same as in normal VSS flight.

The aircraft attitudes and flight conditions attained during this evaluation are not significantly different than those normally demonstrated in the Veridian Engineering Learjet at the United States Air Force and Naval Test Pilot Schools during the past 20 years. The safety pilot monitored aircraft status and flight condition at all times and disengaged the VSS and recover to level flight if an unsafe condition was anticipated. The standard VSS automatic safety trips (see Table 27) were active during these flights and automatically disengaged the VSS and instantaneously returned aircraft control to the safety pilot if any preset value of AOA, G, structural load factor, or undesired control surface activity was reached. The VSS operating envelope is well within the standard Learjet AOA, G, and loads limit envelopes (see Table 27) and at no time were those values exceeded. The hazards on these flights were in no way different than are normally encountered on VSS demonstration flights and were, in fact, somewhat reduced as no VSS operations were planned in close proximity to the ground (i.e., normal VSS demos include landings).

Table 27. Operating and Airspeed Limits

Operating Limits		
Maximum basic airplane g-limits:	Flaps Up:	+4.4 to -1.0 g
	Flaps Down:	+2.0 to -0.0 g
Maximum VSS g-limits:	Flaps Up/Down:	+2.8 to -0.0 g

Airspeed Limitations	
V_A Maneuvering Speed (shown above)	V_A is the highest speed that full aileron and rudder control can be applied without overstressing the aircraft, or the speed at which the aircraft will stall with a load factor of 3.0 gs at maximum gross weight, whichever is less. Therefore, maneuvers involving full control travel or pusher angles-of-attack should be confined to speeds below this value. At test weight V_A is 170 KIAS.
Gear Speed Limit - 200 KIAS	Maximum speed at which the landing gear can be safely extended or retracted.
Flap Speed - 200 KIAS	Maximum speed permissible with the wing flaps in a prescribed extended position (8° & 20°)
Weather Limitations:	Maximum Crosswind limit for VSS Landings - 15 knots Weather minimums for VSS Landings - 700 ft ceiling, 2 nm visibility Visual Flight Rules for demos with discernible horizon

In addition, the minimum altitude during the airplane upset recoveries was 5,000 feet Above Ground Level (AGL). All flights were flown in Visual Flight Rule (VFR) conditions in the presence of a discernable horizon. The flights were flown in the local Buffalo area. The FAA has approved this area for Veridian's Learjet operations.

These safety trip levels well exceed the normal transport category flight envelope and thus do not limit the evaluation pilot inputs during the recoveries from the evaluation scenarios. The Learjet safety trips are designed to protect the Learjet from exceeding structural limits as well. While these limits are outside of normal transport-category flight envelope, no attempt was made to simulate the modeled aircraft structural envelope. In all cases the safety pilot was able to discern whether the correct input was made in the cases before the safety trip was activated.

5. SUMMARY OF RESULTS

The results are presented in four sections: 1) participants' backgrounds, 2) participants' post-flight questionnaire ratings, 3) airplane recovery performance data, and 4) safety pilots' ratings. Descriptive statistics for all variables are presented in Appendix K.

5.1 PARTICIPANTS' BACKGROUNDS

Descriptive statistics were calculated, by group, for data listed on the post-flight questionnaire. Although all evaluation pilots were in their probationary year, there were considerable differences in the number of flight hours they had flown. Flight hours for each of the eight evaluation pilots in each group are presented in Figure 21 as well as the mean ($\overline{X}$) and standard deviation (SD) for each group. Examination of the figure indicates that flight time varied largely between and within groups. This difference was not significant, however (F (4, 30) = 2.532, p = 0.061). Therefore, flight time was not used as a covariate in any of the subsequent analyses. But it should be noted that the evaluation pilot with the lowest number of flight hours (943) was in the in-flight group and the pilot with the highest number of flight hours (12,347) was in the No aero/no upset training group. Evaluation pilots also varied in the amount of flight instruction they had received and/or had given.

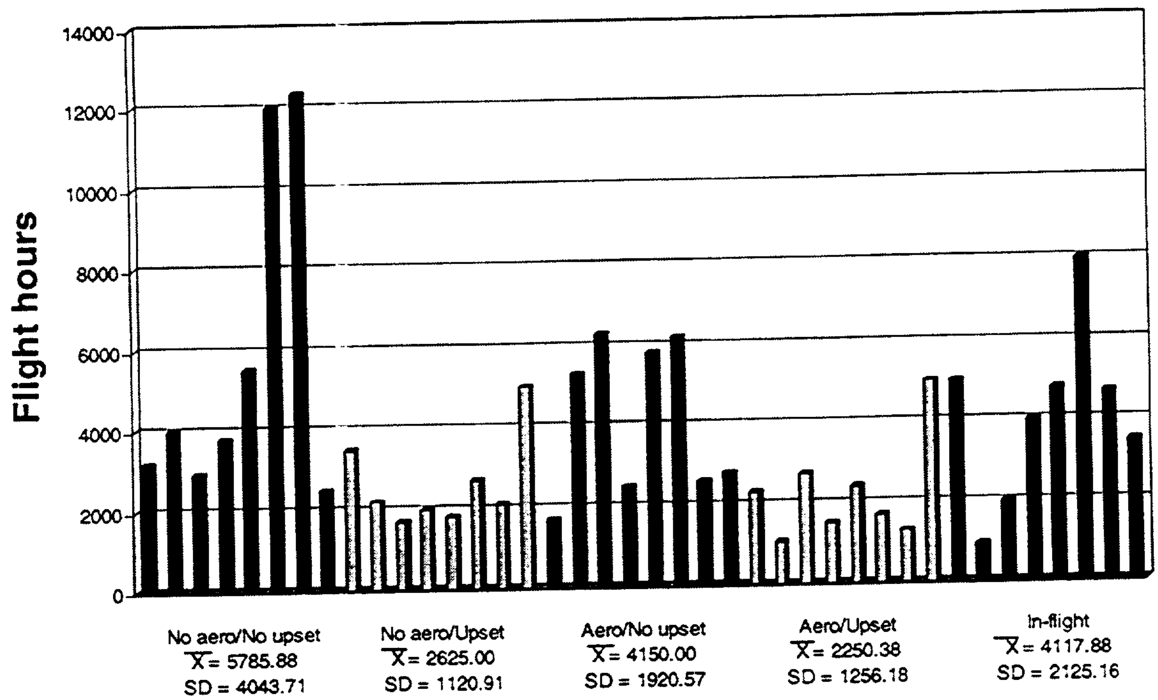

Figure 21. Flight Hours by Group

All evaluation pilots had flown at least two different types of aircraft. The complete list of aircraft flown by evaluation pilot and group is given in Appendix L. Comments made by the evaluation pilots on the post-flight questionnaire are given in Appendix M. Aerobatic experiences also varied considerably by group and are presented in Table 28. Evaluation pilots were classified solely based on their responses during telephone interviews prior to their arrival for the flight test. The criteria for aerobatics experience were: at least six-hours of training completing Aileron Roll, Barrel Roll, Chandelle, Cloverleaf, Cuban Eight, Immelmann, Lazy Eight, Loop, Split S, and Stall Turn maneuvers or experience performing in air shows or stunts in an aircraft with a FAA aerobatic waiver. Later Chandelle and Lazy Eight were identified as part of the required commercial pilot's curriculum but were not performed as aerobatic maneuvers. There were three groups that were to have no aerobatic experience. However this was not the case based on responses from the post-flight questionnaire. Evaluation pilots in the No aero/no upset group had experience in four of the ten maneuvers, specifically, Chandelles (8 evaluation pilots), Lazy Eights (8 evaluation pilots), Loops (1 evaluation pilot), and Stall Turns (3 evaluation pilots). The most recent experience was a Stall Turn performed 21 days prior to the evaluation flight. The No aero/upset group had wider variability in aerobatics experience with 4 evaluation pilots having performed an Aileron Roll, 3 a Barrell Roll, 7 a Cuban Eight, 7 a Lazy Eight, 4 a Loop, 3 a Split S, and 3 a Stall Turn. One evaluation pilot had performed all 10 aerobatic maneuvers. The most recent aerobatic experience by an evaluation pilot in this group was a Lazy Eight performed 3 months prior to the evaluation flight. The third and last group of evaluation pilots who were to have no aerobatic experience were those who received in-flight airplane upset recovery training. In this group 4 performed Aileron Rolls, 1 a Barrell Roll, 1 Loop, 2 Split S, and 6 Stall Turns. All eight had performed Chandelles and Lazy 8s. The most recent experience was a stall turn performed by one evaluation pilot 14 days prior to the

evaluation flight. In all cases evaluation pilots in these groups stated that their aerobatic experience was "trying stuff with a friend". None of their experiences were with instructors or as part of an aerobatics class and therefore were not used as a variate in this study.

Table 28. Days Since Last Performed Aerobatic Maneuver

Group	Aileron Roll	Barrel Roll	Chandelle	Clover-leaf	Cuban Eight	Immelmann	Lazy Eight	Loop	Split S	Stall Turn
No aero/ no upset										
$\bar{X}$	0.00	0.00	2874.38	0.00	0.00	0.00	2746.25	913.00	0.00	430.33
SD	0.00	0.00	2554.53	0.00	0.00	0.00	2638.11	0.00	0.00	367.00
max	0.00	0.00	7300.00	0.00	0.00	0.00	7300.00	913.00	0.00	730.00
min	0.00	0.00	365.00	0.00	0.00	0.00	365.00	913.00	0.00	21.00
No aero/ upset										
$\bar{X}$	775.75	912.67	1095.00	2920.00	2920.00	4380.00	851.43	684.50	851.67	973.33
SD	479.89	482.66	894.06	0.00	0.00	0.00	942.64	524.15	557.55	557.55
max	1460.00	1460.00	2920.00	2920.00	2920.00	4380.00	2920.00	1460.00	1460.00	1460.00
min	365.00	548.00	365.00	2920.00	2920.00	4380.00	120.00	365.00	365.00	365.00
Aero/ no upset										
$\bar{X}$	1207.86	1312.14	680.88	1242.40	1368.83	1564.29	680.88	1312.14	1175.83	605.86
SD	821.20	949.04	856.23	876.57	585.69	689.79	856.23	949.04	780.13	588.23
max	2190.00	2555.00	2190.00	2190.00	2190.00	2555.00	2190.00	2555.00	2190.00	1825.00
min	60.00	60.00	7.00	7.00	730.00	730.00	7.00	60.00	120.00	180.00
Aero/ upset										
$\bar{X}$	1408.00	1544.88	1364.88	1973.80	1644.57	1609.14	1381.13	1408.00	1609.14	1095.57
SD	1641.82	1622.75	1675.64	1903.49	1660.30	1689.98	1662.65	1641.82	1689.98	1879.13
max	5110.00	5110.00	5110.00	5110.00	5110.00	5110.00	5110.00	5110.00	5110.00	5110.00
min	14.00	14.00	14:00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
In-flight										
$\bar{X}$	1368.75	2190.00	1699.38	0.00	0.00	0.00	1516.88	730.00	2555.00	1061.50
SD	752.47	0.00	846.47	0.00	0.00	0.00	688.32	0.00	516.19	1247.10
max	2190.00	2190.00	2920.00	0.00	0.00	0.00	2190.00	730.00	2920.00	2920.00
min	730.00	2190.00	90.00	0.00	0.00	0.00	90.00	730.00	2190.00	14.00

Three evaluation pilots had flown in airshows. The first was in the Aero/no upset group and had performed in an airshow 7 years prior to the evaluation flight. The second and third evaluation pilots who had flown in airshows were in the Aero/upset group. They had flown in the airshows 14 years and 2 weeks, respectively, prior to the evaluation flight. The last evaluation pilot was the only one to have performed stunts in an aircraft with a FAA aerobatic waiver. Again this level of airshow experience, while possibly contributing to the evaluation pilot's overall confidence level, was not used as a variable in this study.

The evaluation pilots also varied in the type of airplane upset recovery training they received. The criteria for airplane-upset training were completion of one of the

following: American Airlines AAMP, Delta CAST, or United Airlines AMP (see descriptions of these training programs in section 1.2.1). There was some airplane upset training in the three groups whose current airlines did not have a formal airplane upset training program. Specifically, in the Aero/no upset group, one evaluation pilot had 1 hour of academic (i.e., class room) training, another 2 hours of academic training but at a previous airline. However, none of the evaluation pilots in either the No aero/no upset nor the In-flight group had any academic airplane upset training. None of the evaluation pilots had been through transition training nor had been through recurrent training, i.e., therefore had not repeated a cycle. Many of the evaluation pilots responded that the instructors at the current airline had airplane upset training even if such training was not provided to all evaluation pilots. The data are summarized in Table 29 and Figures 22, 23, and 24. The responses to the question about the simulators used for the airplane-upset training are summarized in Table 30 and Figure 25. The interest in whether the simulator was owned or leased was based on the flexibility to tailor the simulator to meet the current airplane upset training needs. Leased simulators typically cannot be modified.

Table 29. Number of Evaluation Pilots Agreeing to the Statement Describing Their Airplane Upset Recovery Training

Group	Transition Training	Repeated Each Cycle	Instructor Training
No aero/no upset			
No	6	6	4
Yes	2	1	0
Don't know	0	1	4
No aero/upset			
No	1	6	2
Yes	4	1	3
Don't know	3	1	3
Aero/no upset			
No	5	5	1
Yes	1	1	1
Don't know	2	2	6
Aero/upset			
No	1	2	1
Yes	1	0	1
Don't know	6	6	6
In-flight			
No	5	4	0
Yes	0	0	0
Don't know	3	4	8

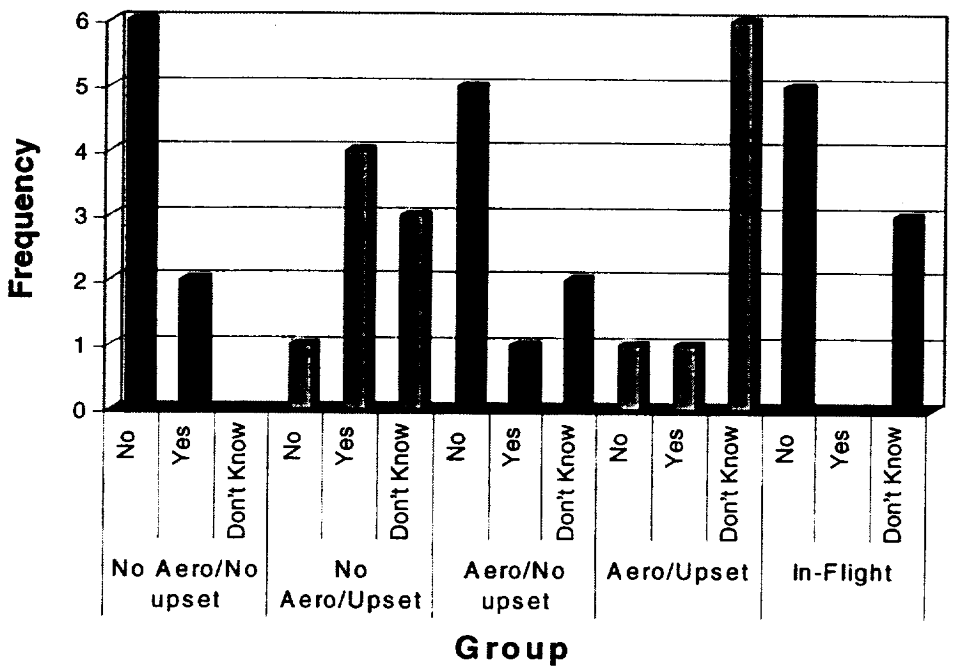

Figure 22. Airplane Upset Recovery Training Provided During Transition

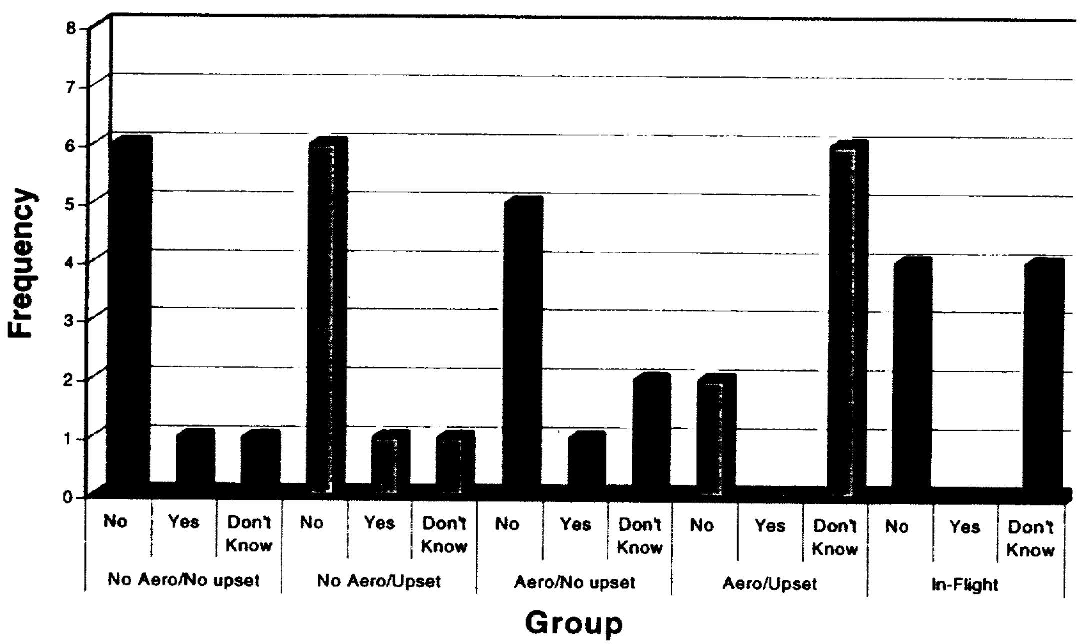

Figure 23. Airplane Upset Recovery Training Repeated Each Cycle

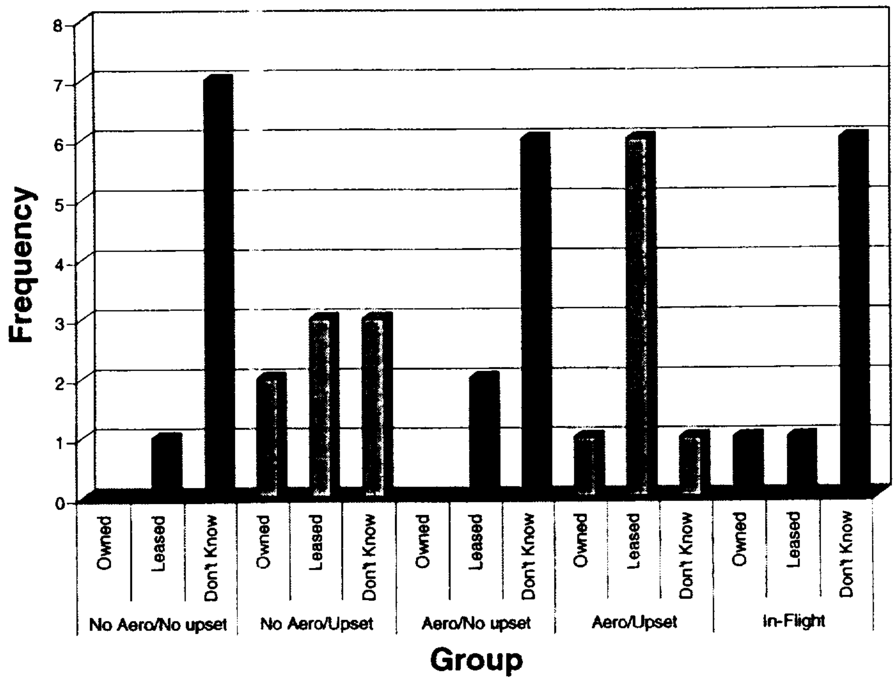

Figure 24. Airplane Upset Recovery Training Provided to Instructors

Table 30. Number of Evaluation Pilots Agreeing to the Statement Describing Simulators Used During Airplane Upset Recovery Training

Group	Simulator
No aero/no upset	
Owned	0
Leased	1
Don't know	7
No aero/upset	
Owned	2
Leased	3
Don't know	3
Aero/no upset	
Owned	0
Leased	2
Don't know	6
Aero/upset	
Owned	1
Leased	6
Don't know	1
In-flight	
Owned	1
Leased	1
Don't know	6

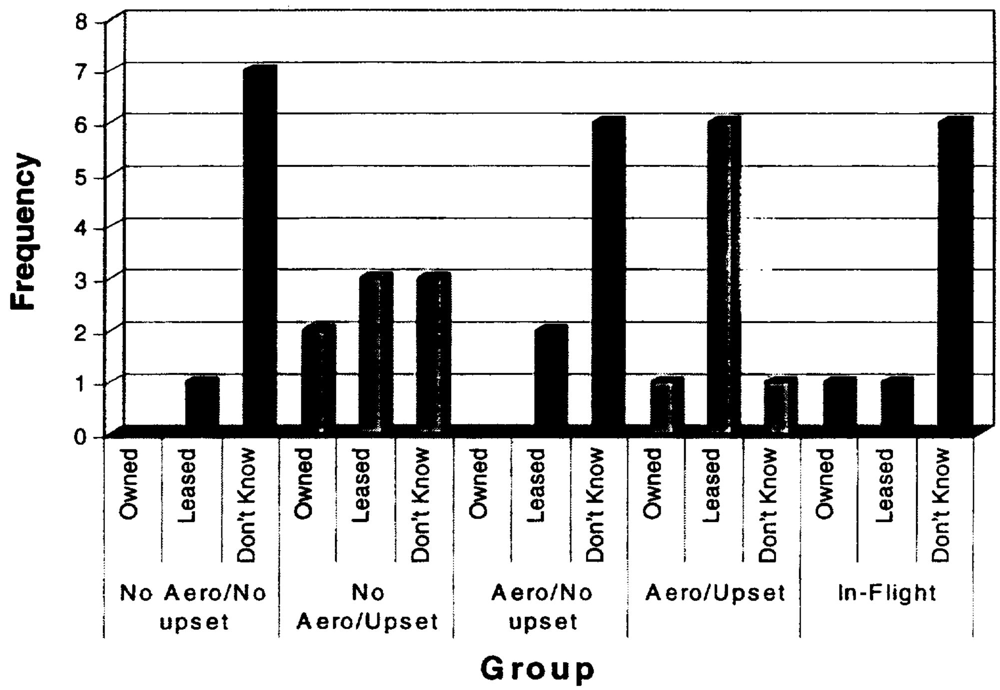

Figure 25. Status of Simulators Used for Airplane Upset Recovery Training

5.2 POST-FLIGHT QUESTIONNAIRE RATINGS

The evaluation pilots rated their confidence to recover from an upset as well as the value of the four types of aircraft recovery training on a scale from 1 (low) to 10 (high). Confidence was in the mid ($\overline{X}$ = 6.87 for the No aero/no upset group) to high ($\overline{X}$ = 8.375 for the In-flight group) range. The value of aerobatics was rated highest by the Aero/upset group ($\overline{X}$ = 8.75) and lowest by the No aero/no upset group ($\overline{X}$ = 5.5). The value of simulator training was rated highest by the No aero/upset group ($\overline{X}$ = 8.5) and lowest by the Aero/no upset group ($\overline{X}$ = 6.75). The value of in-flight training was unanimously rated 10 by the In-flight group. The No aero/no upset group rated its value the lowest ($\overline{X}$ = 8.75). The desire for additional training was rated high among all five groups with the No aero/no upset group lowest ($\overline{X}$ = 9.5) and three groups giving it unanymous ratings of 10 (No aero/upset, Aero/no upset, In-flight). This overwhelming desire for training indicates the need for changes in the way pilots are currently being prepared for air-transport employment. The results of analyses of variance (anovas) calculated on these five ratings are presented in Table 31. There were no significant differences among the five groups.

Table 31. ANOVA and Summary Tables for Ratings on Training

Confidence to Recover from an Upset

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	10.650	4	2.663	0.839	0.510	2.641
Within Groups	111.125	35	3.175			
Total	121.775	39				

Groups	*Average*	*Variance*
No Aero/No Upset	6.875	4.411
No Aero/Upset	7.500	4.000
Aero/No Upset	7.250	2.500
Aero/Upset	7.125	3.554
In-flight	8.375	1.411

Value of Aerobatic Experience

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	67.1	4	16.775	1.583	0.200	2.641
Within Groups	370.875	35	10.596			
Total	437.975	39				

Groups	*Average*	*Variance*
No Aero/No Upset	5.500	14.571
No Aero/Upset	6.500	20.286
Aero/No Upset	8.250	5.071
Aero/Upset	8.750	0.786
In-flight	8.625	12.268

Value of Simulator Training

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	21.650	4	5.413	0.680	0.611	2.641
Within Groups	278.750	35	7.964			
Total	300.400	39				

Groups	*Average*	*Variance*
No Aero/No Upset	7.625	2.554
No Aero/Upset	8.500	5.143
Aero/No Upset	6.750	11.071
Aero/Upset	7.250	9.357
In-flight	6.375	11.696

Value of In-Flight Training

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	6.750	4	1.688	1.890	0.134	2.641
Within Groups	31.250	35	0.893			
Total	38.000	39				

Groups	*Average*	*Variance*

No Aero/No Upset	8.750	2.214
No Aero/Upset	9.625	1.125
Aero/No Upset	9.625	0.554
Aero/Upset	9.500	0.571
In-flight	10.000	0.000

Desire for More Training

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	1.900	4	0.475	1.400	0.254	2.641
Within Groups	11.875	35	0.339			
Total	13.775	39				

Groups	*Average*	*Variance*
No Aero/No Upset	9.500	0.571
No Aero/Upset	10.000	0.000
Aero/No Upset	10.000	0.000
Aero/Upset	9.625	1.125
In-flight	10.000	0.000

A two-factor anova was calculated on the rated difficulty of the scenario (1 = low, 10 = high). The factors were group and scenario. The results are presented in Table 32. There was no significant main effect of group. Nor was the interaction between the two factors significant. However, there was a significant effect of scenario. Charlotte was rated as easiest and all but one evaluation pilot recovered from this windshear scenario. Pittsburgh was rated as the most difficult. Simply put, the Charlotte windshear scenario was one that was not only well understood, discussed and practiced, it required only a "mechanical-type" recovery. The Pittsburgh scenario, on the other hand, not only was more startling but also required non-intuitive pilot inputs to expedite a recovery. A Scheffé post hoc analysis was calculated. None of the means were significantly different. Therefore, only Charlotte and Pittsburgh are significantly different as indicated by the anova.

Table 32. ANOVA and Summary Tables for Ratings on Scenario Difficulty

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Group	12.956	4	3.239	0.540	0.707	2.404
Scenario	302.372	7	43.196	7.197	0.000	2.042
Interaction	219.144	28	7.827	1.304	0.146	1.517
Within	1680.625	280	6.002			
Total	2215.097	319				

Group	Statistic	Difficulty of Birmingham	Difficulty of Toledo	Difficulty of Nagoya	Difficulty of Roselawn	Difficulty of Detroit	Difficulty of Schemya	Difficulty of Charlotte	Difficulty of Pittsburgh
No Aero/No Upset	Average	5.625	5.250	6.375	6.500	6.500	7.375	4.625	9.875
	Variance	1.125	3.357	2.839	11.429	5.714	7.125	4.839	0.125
No Aero/Upset	Average	6.750	5.000	5.625	8.375	8.000	5.500	4.750	8.250

	Variance	1.929	11.429	10.268	1.411	3.143	8.286	6.500	2.500
Aero/No Upset	Average	6.500	4.875	7.000	6.500	5.750	6.625	4.250	8.375
	Variance	2.571	6.125	5.429	3.143	2.214	3.125	2.500	4.554
Aero/Upset	Average	5.875	5.125	7.375	8.750	6.875	6.500	5.875	8.500
	Variance	1.268	4.411	1.411	17.643	1.268	7.714	2.125	2.286
In-flight	Average	6.000	8.750	5.500	6.750	6.750	6.000	5.750	7.500
	Variance	10.857	3.357	10.857	14.214	14.786	16.286	8.500	11.429

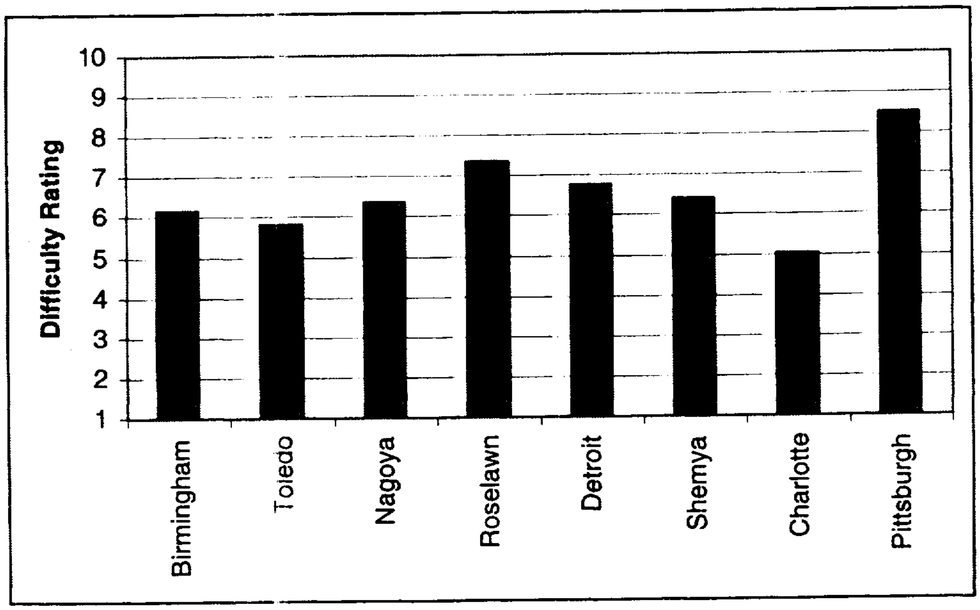

Figure 26. Difficulty Rating as a Function of Scenario

The evaluation pilots were also asked to rank the effectiveness of four types of airplane-upset training (aerobatics, simulator, aerobatics and simulator, and in-flight) from 1 (best) to 4 (worst). A two-factor anova was calculated on these data. The factors were scenarios and type of training. There was no significant effect of scenarios. There were significant effects for type of training and for the interaction of scenarios and type of training. For type of training, the rankings from best to worst were: in-flight ($\bar{X}$ = 1.800), aerobatics with simulator ($\bar{X}$ = 2.075), aerobatics ($\bar{X}$ = 3.025), and simulator $\bar{X}$ = 3.000). A Scheffé post hoc analysis was performed. There were no significant differences in these four types of training. The rankings by group and type of training are plotted in Figure 27. In-flight simulation was ranked as the best type of training by all but the Aero/upset group (group that received ground-simulator upset training) that ranked aerobatics with simulator training as best. The Aero/upset also ranked aerobatics higher than in-flight simulation but none of the other groups did. Comments during the debriefing also indicated that aerobatics were not perceived as useful as thought prior to the evaluation flight. This supports some opinions that aerobatics, in an aircraft that does not closely duplicate the environment and responses of a transport category aircraft, does little more than reduce some of the fear of unusual attitudes and may even reinforce false perceptions of control effectiveness and the importance of correct sequencing of control inputs.

Table 33. ANOVA and Summary Tables for Rankings on Type Training

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Scenario	0.400	4	0.100	0.122	0.975	2.436
Type Training	47.750	3	15.917	19.335	0.000	2.669
Interaction	32.500	12	2.708	3.290	0.000	1.822
Within	115.250	140	0.823			
Total	195.900	159				

Group	Aero Training	Sim Training	Aero & Sim Training	In-Flight Training
No Aero/No Upset	3.500	2.375	2.125	2.000
No Aero/Upset	3.250	3.000	2.000	1.750
Aero/No Upset	3.250	3.750	1.750	1.250
Aero/Upset	2.125	3.250	1.625	2.500
In-flight	2.875	2.750	2.875	1.500

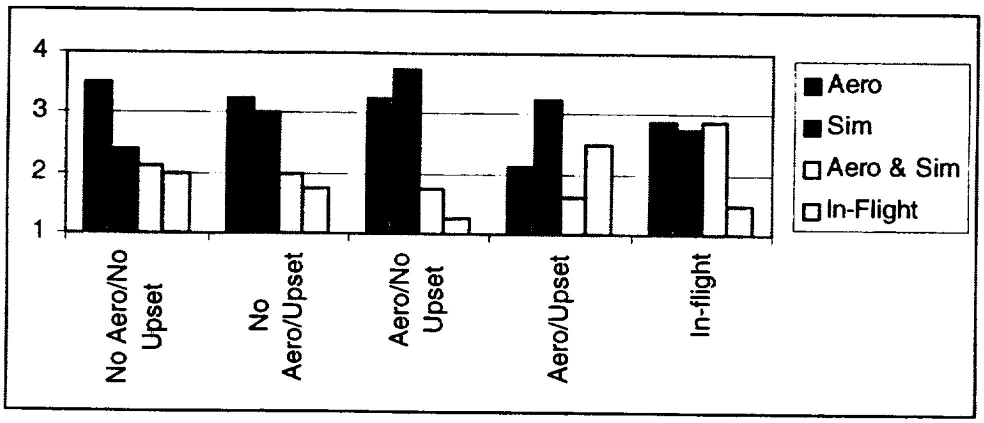

Figure 27. Ranking (1 = best, 4 = worst) by Group and Type of Training

5.3 RECOVERY PERFORMANCE

Recovery performance is discussed separately for each of the eight evaluation scenarios. Each discussion includes a presentation of the complete recovery performance and the results of all analyses of variance (anovas) of responses as a function of type of airplane upset training (no aero/no upset, no aero/upset, aero/no upset, aero/upset, and in-flight). Note that the recovery data identify how closely the evaluation pilots adhered to the recovery procedures developed and agreed upon by the consortium as listed above. However, there are no data on the accuracy of these procedures or on how closely pilots must adhere to them (what tolerances there are) to recover an aircraft to straight and level flight. Nor was the amplitude of pilot inputs collected, reduced, or analyzed. This study is the first to test the procedures and to measure the adherence of pilots to these procedures. Further, it is imperative that the order of the procedures is aircraft independent – the timing (how much and how long to maintain the input) however, is invariably both aircraft and condition dependent. Note also that safety pilot and flight test engineer scripts introducing the scenario are presented in Appendix D (section 11) and transcripts of the audio portion of the evaluation flights are presented in Appendix L.

5.3.1 Birmingham

This accident occurred during an instrument landing approach in severe turbulence. The correct recovery performance and the variables used to quantify that performance (see Table 34) were:

1. Announce problem.
   a. Time to announce problem
2. Initially requires full aileron input to fight uncommanded roll.
   a. Time to correct aileron input
   b. Time to correct rudder input
3. Full down elevator with trim to keep the AOA within limits.
   a. Time to correct elevator input
   b. Time to trim input
4. Use bank angle as required to control flight path.
   a. Adjust phi to control gamma
5. Airspeed should maintain safe margin above accelerated stall speed.
   a. Airspeed > stall

Birmingham was an extremely difficult scenario from which to recover. In fact only four evaluation pilots recovered from this airplane upset: 1 in the No Aero/No Upset group, 1 in the No Aero/Upset group, and 2 in the In-flight group. This is 11% of the pilots. The most common mistake among evaluation pilots was not using bank angle to change the direction of the lift vector to recover from the initial pitch upset (see adjust phi to control gamma variable in Table 34).

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.1). A summary of the recovery data is presented in Table 34. Means and standard deviations by group are presented in Table 35. There were no significant differences between groups in any of the recovery data. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and those who did not. Means and standard deviations by recovery outcome are presented in Table 36. Values that are significantly different are shaded.

Birmingham was also one of the evaluation scenarios that was used as a "surprise." The surprise occurred during the return to base after completion of the eight scenarios. The performance data for the surprise are presented in Table 37. During the surprise, for those evaluation pilots who announced the problem, they did so sooner than during the first eight evaluation scenarios. However, they took longer to put in correct aileron and rudder input. The evaluation pilots from the In-flight group used bank angle to control angle of attack, as did one evaluation pilot from the No Aero/Upset and one evaluation pilot from the Aero/Upset groups. One safety trip affected recovery performance after 3.9 seconds so only the initial inputs were collected. The others did not occur until about 19 seconds into the recovery. Only one evaluation pilot recovered from the Birmingham surprise scenario. The evaluation pilot was from the in-flight group.

Table 34. Performance Data for Birmingham

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Elevator Input (sec)	Time to Trim Input (sec)	Adjust Phi to Control Gamma Yes/No	A/S > stall Yes/No	Recovered[110]	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
No Aero/No Upset	5.65	2.4	2.5	5.83				No	Yes - 6.40	Yes
No Aero/No Upset	2.25	0.65	0.65	3.45		Yes		No	Yes - 5.35	Yes - End
No Aero/No Upset	0.85	0	0.1	3.65		No	No	No	Yes - 7.15	No
No Aero/No Upset	1.1	0.65	0.9	3.8				No	Yes - 5.20	Yes
No Aero/No Upset	2.2	0	0.6	4	7	No	Yes	Yes	No	No
No Aero/No Upset	5.6	0.1	0.2	5.2	9.15	No	No	No	No	No
No Aero/No Upset	11.85	1.1	1.35	5.1		Yes		No	Yes - 12.45	Yes - End
No Aero/No Upset		0.15	0.25	4.4				No	Yes - 10.70	Yes - End
Aero/No Upset		0.75	0.95	2.9				No	Yes - 5.05	Yes
Aero/No Upset	0.65	0	0.15	2.9		Yes		No	Yes - 8.15	Yes - End
Aero/No Upset		0	0.1	4.5		No	No	No	No	No
Aero/No Upset		0	0.2	4.35		No	No	No	Yes - 11.80	No
Aero/No Upset	3.5	0	0.25	5.85		No	No	No	Yes - 9.75	No
Aero/No Upset	5.9	0.35	0.45	3.4	11.35	No	No	No	Yes - 19.05	No
Aero/No Upset		0	0.1	4		No	No	No	Yes - 10.03	No
Aero/No Upset[111]										
No Aero/Upset	0.75							No	Yes - 1.50	Yes
No Aero/Upset		0	0.2	3		No	No	No	Yes - 8.25	No
No Aero/Upset	0.65	0.15	0.15	4.85	8.6	No	Yes	Yes	No	No
No Aero/Upset	11.25	0.1	0.25	5.45	9.1	Yes		No	Yes - 18.35	Yes - End
No Aero/Upset		0.05	0.25	4.6		Yes		No	Yes - 12.50	Yes - End
No Aero/Upset	-0.8	0	0.25	3.7		No	No	No	Yes - 11.50	No
No Aero/Upset[112]										

[110] Stabilized flight within the normal flight envelop for transport category aircraft.
[111] Data missing due to computer failure during flight.
[112] Data missing due to computer failure during flight.

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Elevator Input (sec)	Time to Trim Input (sec)	Adjust Phi to Control Gamma Yes/No	A/S > stall Yes/No	Recovered[116]	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
No Aero/Upset[113]										
Aero/Upset	1.55	0.5	0.55	4.1				No	Yes - 4.55	Yes
Aero/Upset	1	0	0	4	5.1	Yes	Yes	No	Yes - 17.35	No
Aero/Upset	10.05	0.05	0	4.05		Yes		No	Yes - 14.65	Yes - End
Aero/Upset	2.5	0.1	0	4.45		No	No	No	Yes - 12.80	No
Aero/Upset	1.45	0.9	1.2	4.71		No	No	No	Yes - 12.45	No
Aero/Upset	1.2	0	1.25	3.65		Yes	Yes	No	Yes - 14.45	No
Aero/Upset	0.95	0.2	0	5.95		No	No	No	No	No
Aero/Upset[114]										
In-flight	6.65	0	0.2	4.9		Yes	Yes	No	Yes - 15.60	No
In-flight	1.6	0.05	0.35	3.85	9.8	Yes	Yes	No	Yes - 17.85	No
In-flight	1.35	0.55	0.65	3.95	6.85	No	Yes	Yes	No	No
In-flight	0.95	0.05	0.35	4.2	8.65	Yes	Yes	No	Yes - 16.04	No
In-flight	0.85	0	0.05	3.95	10.45	No	No	No	No	No
In-flight	2.65	0	0.75	4.5	9.6	Yes	Yes	Yes	No	No
In-flight	-0.1	0.05	0.2	3.4	9.35	No	No	No	No	No
In-flight[115]										

[113] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[114] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[115] Data missing due to wheel column breaking during flight.

Table 35. Group Mean and Standard Deviation for Performance Data for Birmingham

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Elevator Input (sec)	Time to Trim Input (sec)	Adjust Phi to Control Gamma Yes/No	Recovered	A/S > stall Yes/No	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
No Aero/No Upset										
Mean	4.214	0.631	0.819	4.429	8.075	2 out of 7	1 out of 8	1 out of 7	6 out of 7	5 out of 7
Standard Deviation	3.899	0.816	0.794	0.858	1.520					
N	7	8	8	8	2					
Aero/No Upset										
Mean	3.350	0.157	0.314	3.986	11.350	1 out of 7	0 out of 7	0 out of 7	7 out of 7	2 out of 7
Standard Deviation	2.628	0.292	0.305	1.047	-					
N	3	7	7	7	1					
No Aero/Upset										
Mean	2.963	0.060	0.220	4.320	8.850	2 out of 7	1 out of 6	1 out of 7	6 out of 7	3 out of 7
Standard Deviation	5.570	0.065	0.045	0.970	0.354					
N	4	5	5	5	2					
Aero/Upset										
Mean	2.671	0.250	0.429	4.416	5.100	2 out of 7	0 out of 7	2 out of 7	2 out of 7	2 out of 7
Standard Deviation	3.295	0.335	0.580	0.757	-					
N	7	7	7	7	1					
In-flight										
Mean	1.993	0.100	0.364	4.107	9.117	4 out of 7	2 out of 7	5 out of 7	3 out of 7	0 out of 7
Standard Deviation	2.216	0.200	0.253	0.484	1.256					
N	7	7	7	7	6					

Table 36. Group Mean and Standard Deviation for Recovery Data for Birmingham[116]

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Elevator Input (sec)	Time to Trim Input (sec)	Adjust Phi to Control Gamma Yes/No	A/S > stall Yes/No	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
Recovery									
Mean	1.713	0.175	0.538	4.325	8.013	1 yes 3 no	4 yes 0 no	[illegible]	0 yes 4 no
Standard Deviation	0.890	0.260	0.266	0.429	1.322				
N	4	4	4	4	4	4	4	4	4
No Recovery									
Mean	3.217	0.273	0.442	4.243	9.119	11 yes 14 no	5 yes 14 no	[illegible]	12 yes 19 no
Standard Deviation	3.618	0.506	0.547	0.848	1.838				
N	24	30	30	30	8	25	19	30	31

[116] Shading indicates significant difference.

Table 37. Performance Data for Birmingham Surprise Scenario

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Elevator Input (sec)	Time to Trim Input (sec)	Adjust Phi to Control Gamma Yes/No	A/S > stall Yes/No	Recovered[117]	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
No Aero/No Upset	2.750	0.300	0.400	3.200		No	No	No	Yes - 19.150	No
No Aero/Upset	0	0.200	0.500	3.250	6.110	Yes	Yes	No	No	No
Aero/No Upset		0	0.150	4.050				No	Yes -3.900	Yes
Aero/Upset	2.250	0.500	0.200	4.900	6.400	Yes	Yes	No	Yes - 18.800	No
Aero/Upset	0	0.400		3.450	9.100	No	No	No	No	No
Aero/Upset	0	0	0	4.600	12.200	No	No	No	No	No
In-flight	0	0.150		4.800	9.100	Yes	No	Yes	No	No

[117] Stabilized flight within the normal flight envelop for transport category aircraft.

Two sets of analyses were performed – those to evaluate the effects of different types of training (training effects) and those to identify differences in performance between evaluation pilots who recovered and those who did not (recovery differences). Each of these is discussed in a separate section below.

5.3.1.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.1.1.1 Announce problem

The first variable of interest was time to announce the problem. An anova was calculated to determine the effect of type of training. The effect was not significant ($F(4, 23) = 0.364$, $p = 0.831$). Of note is that seven out of the seven evaluation pilots in three of the groups (No Aero/No Upset, Aero/Upset, and In-flight) responded while only about half in the remaining two groups responded (3 out of 7 Aero/No Upset and 4 out of 7 No Aero/Upset). This did not consistently follow the training since evaluation pilots without upset training have not been instructed to announce a problem while those with training have been.

5.3.1.1.2 Initially requires full aileron input to fight uncommanded roll

Of primary interest was the evaluation pilot's time to initial control inputs. There were no significant effects of training on either of these dependent variables: aileron ($F(4, 29) = 1.849$, $p = 0.147$) or rudder ($F(4, 29) = 1.508$, $p = 0.226$).

5.3.1.1.3 Full down elevator with trim to keep the AOA within limits

There was no significant difference among the five training groups in the time to input a correct elevator input ($F(4, 29) = 0.394$, $p = 0.811$). The use of trim was not analyzed since only a few evaluation pilots used this control (1 out of 7 in Aero/No Upset and Aero/Upset, 2 out of 7 in No Aero/No Upset and No Aero/Upset, and 6 out of 7 in In-flight).

5.3.1.1.4 Use bank angle as required to control flight path

A primary recovery technique is the use of bank angle (phi) to control angle of attack (gamma). Very few evaluation pilots (one or 2 per group) used this technique except in the In-flight group in which 4 out of the 7 evaluation pilots used bank angle.

5.3.1.1.5 Airspeed should maintain safe margin above accelerated stall speed

Maintaining airspeed above stall is another technique critical to airplane recovery. Again very few evaluation pilots used this technique (none from Aero/No Upset, one each from No Aero/No Upset and No Aero/Upset, two from Aero/Upset, and five from In-flight). It is not surprising that the evaluation pilots who did use the technique were in the Aero/Upset and In-flight training groups since this technique seems to require both academic training and in-flight experience.

5.3.1.1.6 Safety trips and comments

Safety trips occurred in the majority of the recoveries (6 for the No Aero/No Upset, No Aero/Upset, and Aero/Upset groups, 7 in the Aero/No Upset group) in all but the In-flight group (3). These affected the recovery in 12 out of 35 cases, however, and the majority of these at the very end of the recovery. The modeled flight condition was close to the Learjet AOA safety trip limit and in order to present a realistic scenario any hesitation on the evaluation pilot's input to reduce AOA due to the turbulence resulted in the above mentioned safety trip being activated. The Learjet AOA safety trip is not far from the modeled airplane (Beech 99) stall limit and thus any hesitation in the evaluation pilot's input to reduce AOA (as in the actual accident) would cause a stall. In all cases the safety trip that was activated was greater than +10 degrees AOA – again reinforcing the fact that very few evaluation pilots used maximum elevator control and bank angle to reduce AOA. Comments regarding individual recoveries are presented in Table 38. Recoveries ranged from using trim after full forward wheel column was attained to using emergency trim after rolling the aircraft.

Table 38. Comment on Airplane Upset Recovery Performance Data for Birmingham

Group	Recovered	Safety Trip - Yes (sec)	Safety Trip Affect Recovery	Comments
No Aero/No Upset	No	Yes - 6.40	Yes	Moderate turbulence only (seemed heavy); VSS trip on AOA in pitch up following roll.
No Aero/No Upset	No	Yes - 5.35	Yes - End	Light turbulence only. VSS trip on AOA and das in pitch up following roll.
No Aero/No Upset	No	Yes - 7.15	No	Light turbulence only. VSS trip on AOA in pitch up following roll. Pitch up amplitude seemed about right. EP used full forward stick.
No Aero/No Upset	No	Yes - 5.20	Yes	Light turbulence only. VSS trip on AOA and das in pitch up following roll.
No Aero/No Upset	Yes	No	No	EP used trim after full forward on wheel column to recover.
No Aero/No Upset	No	No	No	EP added max power, then reduced power. No good so EP powered back up. SP took control nose high just as VSS tripped on AOA.
No Aero/No Upset	No	Yes - 12.45	Yes - End	190 KIAS Initial Condition. EP asked SP to disconnect pitch trim as VSS tripped on AOA with nose high.
No Aero/No Upset	No	Yes - 10.70	Yes - End	EP inadvertently pushed VSS dump button while pushing on yoke. Attitude was nose high.
Aero/No Upset	No	Yes - 5.05	Yes	Light turbulence only. VSS trip on AOA and das in pitch up following roll.
Aero/No Upset	No	Yes - 8.15	Yes - End	Light turbulence only. VSS trip on AOA in pitch up following roll. Pitch up amplitude is smaller than previous but still too big to prevent VSS trip.
Aero/No Upset	No	No	No	SP took control with nose high. No trim use or roll.

Aero/No Upset	No	Yes - 11.80	No	EP-induced roll oscillation while in climb. VSS trip on AOA. Pitch-up OK.
Aero/No Upset	No	Yes - 9.75	No	190 KIAS Initial Condition. EP called to set max thrust. EP full forward on wheel with nose still was coming up when SP took control. No roll.
Aero/No Upset	No	Yes - 19.05	No	VSS trip on AOA with nose high. EP called for emergency trim. No roll.
Aero/No Upset	No	Yes - 10.03	No	EP added power and mentioned that he (she) was "climbing deliberately." VSS tripped on AOA with nose high. No roll.
Aero/No Upset				
No Aero/Upset	No	Yes - 1.50	Yes	VSS tripped.
No Aero/Upset	No	Yes - 8.25	No	Repeat
No Aero/Upset	Yes	No	No	EP asked about turbulence penetration speed. EP pushed power up. Recognized "runaway trim." Used trim to recover.
No Aero/Upset	No	Yes - 18.35	Yes - End	EP called for emergency trim and just started to roll right when VSS tripped on AOA with nose high. SP was about ready to take control.
No Aero/Upset	No	Yes - 12.50	Yes - End	VSS trip on AOA with nose high. Nose seemed to pitch up rapidly just before VSS trip. EP commented in post-flight that he/she was thinking about rolling (check record).
No Aero/Upset	No	Yes - 11.50	No	EP pushed power up and called for emergency trim as VSS tripped on AOA. No roll.
No Aero/Upset				
No Aero/Upset				
Aero/Upset	No	Yes - 4.55	Yes	VSS trip on AOA and das. Upset injected just as localizer came alive.
Aero/Upset	No	Yes - 17.35	No	Light turbulence only. VSS trip on AOA in pitch up following roll. Pitch upset was OK (maybe even a little too slow) but VSS tripped on AOA nose high.
Aero/Upset	No	Yes - 14.65	Yes - End	EP pulled power back in roll upset. Set max power in climb. Started to roll left but too late. VSS tripped on AOA.
Aero/Upset	No	Yes - 12.80	No	EP set max power initially then pulled power back in climb. SP took control with nose high, power back, airspeed decreasing.
Aero/Upset	No	Yes - 12.45	No	VSS trip on AOA in the pitch up just as EP asked for emergency trim.
Aero/Upset	No	Yes - 14.45	No	VSS trip on AOA in climb.
Aero/Upset	No	No	No	EP added max power. Got into significant roll oscillation after roll upset. VSS trip on AOA in climb. EP called for emergency trim just as VSS tripped.
Aero/Upset				

In-flight	No	Yes - 15.60	No	EP banked left during pitch up. VSS trip on AOA in turn.
In-flight	No	Yes - 17.85	No	EP called for continuous ignition on after turbulence report. EP used full forward column, called for emergency trim, and rolled left before VSS tripped on AOA.
In-flight	Yes	No	No	EP used emergency trim to recover from pitch up.
In-flight	No	Yes - 16.04	No	EP called "trim runaway." EP rolled left before VSS tripped on AOA.
In-flight	No	No	No	EP disconnected automation quickly. Called for missed approach. VSS trip on AOA with nose high after EP just called for emergency trim.
In-flight	Yes	No	No	EP rolled aircraft and called for emergency trim to recover nicely.
In-flight	No	No	No	SP took control after VSS trip on AOA with nose very high.
In-flight				

5.3.1.2 Recovery Differences

The performance of those evaluation pilots who recovered (4) and those who did not (24) was compared using a series of one-way anovas. There were no significant differences in time to announce the problem ($F(1, 26) = 0.665$, $p = 0.422$). Nor for any of the control input times (aileron $F(1, 32) = 0.143$, $p = 0.708$), rudder $F(1, 32) = 0.117$, $p = 0.735$, elevator $F(1, 32) = 0.035$, $p = 0.852$), and trim $F(1, 10) = 1.130$, $p = 0.313$). Chi Square analysis was used to compare the number of evaluation pilots who used bank angle to control AOA in both the recovery and no recovery groups. Again, there was no significant difference ($\chi^2(1) = 0.513$, $p \leq 1.000$). However, there was a significant difference for maintaining airspeed above stall ($\chi^2(1) = 9.852$, $p \leq 0.010$). Recovery from imminent stall is a combination of timing, sequence, and amplitude of input. There were no significant differences in time and sequence but amplitude was not assessed. The fact that an AOA safety trip occurred on a majority of these recoverable evaluations indicates that the amplitude of the elevator and/or bank angle input (i.e., the aggressiveness of the recovery technique) was insufficient. This behavior was incorporated into the safety pilot rating.

Finally, Chi Square analyses were also used to assess the relationship between safety trips and recovery. Evaluation pilots who had not recovered were significantly more likely to have safety trips ($\chi^2(1) = 14.733$, $p \leq 0.001$). This is not surprising since these evaluation pilots failed to make the appropriate size inputs to reduce AOA. This is an indication of the reluctance of transport pilots to make control inputs even when required. However, there was no significant relationship between safety trips that might have affected recovery and the recovery itself ($\chi^2(1) = 2.356$, $p \leq 0.200$).

Confusion was prevalent for those evaluation pilots who did not recover. This was evidenced by rapid switches between power settings, inadvertent activation of controls, failure to use trim or roll during pitch up, and occurrences of roll oscillations.

While confusion in the cockpit in emergency situations is not unusual, the degree of confusion noted by the safety pilots was much more indicative of real-world scenarios than that noted during ground-based upset recovery training.

5.3.2 Toledo

This accident occurred after executing a second missed approach in which the captain became spatial disoriented. The correct recovery performance and the variables used to quantify that performance (see Table 39) were:

1. Announce problem (e.g., "attitude").
   a. Time to announce problem
2. Crosscheck instruments.
3. Disconnect autopilot.
   a. Time to master disconnect
4. Aggressively roll right to approximately wings level.
   a. Time to correct aileron input
5. Use rudder to enhance roll rate.
   a. Time to correct rudder input
6. Retard power to remain near corner speed.
   a. Time to correct throttle input
   b. Delta from 210 KIAS comer speed
7. Full aft column and nose-up trim to 2.5 g pull up.
   a. Time to correct elevator input
   b. Time to trim input
   c. Maximum normal acceleration
8. Maintain climb until 1500 AGL.
   a. Altitude lost

The above recovery procedure mimics the standard operating procedure for pilot not flying in cases of pilot flying disorientation. It begins with questioning attitude (step 1), verifying attitude (step 2), and then taking control (step 3).

This scenario was recovered[118] by a large majority of evaluation pilots (30 out of 35 for whom there were complete data sets, i.e., 86%). Only 5 evaluation pilots did not recover – 1 from the No Aero/No Upset group, 2 from the Aero/No Upset group, and 2 from the In-flight group. All 5 were due to safety trips encountered less than 23 seconds into the scenario. In each case the evaluation pilot waited too long to intervene (time to correct aileron input) and then did not pull hard enough to recover (maximum normal acceleration). This is the same behavior as shown by the crew in the actual accident.

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.2). A summary of the recovery data is presented in Table 39. Means and standard deviations by group are presented in Table 40. There were no significant differences among training groups. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and those who did not. Means and standard deviations

[118] Aircraft returned to straight and level flight.

by recovery outcome are presented in Table 41. Values that are significantly different are shaded.

Table 39. Performance Data for Toledo

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Aileron Input (sec)[119]	Time to Correct Rudder Input (sec)	Time to Correct Throttle Input (sec)	Delta from 210 Corner Speed (KIAS)	Time to Correct Elevator Input (sec)	Time to Trim Input (sec)	Maximum Normal Acceleration (g)	Altitude Lost (ft)	Recovered[120]	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
No Aero/No Upset	1.55		4.25	3.85	13.35	65	6.20		2.11	1243.98	Yes	No	No
No Aero/No Upset	4.75	7.85	4.65	4.90	7.75	40	7.55		2.53	1054.90	Yes	Yes - 7.75	Yes
No Aero/No Upset	4.35		4.05	4.60	29.30	20	4.75		1.83	454.99	Yes	No	No
No Aero/No Upset	4.60		3.90	4.20	8.10	10	3.95	7.60	1.53	339.32	Yes	No	No
No Aero/No Upset	1.25		2.85	2.85							No	Yes - 4.85	Yes
No Aero/No Upset	1.80		3.70	3.60	11.30	40	6.65		1.86	768.00	Yes	No	No
No Aero/No Upset[121]													
No Aero/No Upset[122]													
Aero/No Upset	4.60		5.80	7.55	8.65	40	6.40		2.00	1517.25	Yes	No	No
Aero/No Upset	3.90		4.00	3.95	25.35	20	4.00		1.91	460.29	Yes	No	No
Aero/No Upset	3.85		7.65	8.95		110	9.85		3.43	2806.00	No	Yes - 18.50	No
Aero/No Upset	4.50		4.75	4.80	18.05	20	6.85		2.17	323.33	Yes	No	No
Aero/No Upset	3.65		3.55	3.50	14.85	30	4.85		1.60	378.96	Yes	Yes - 22.80	No
Aero/No Upset	1.15		4.25	4.20	32.10	65	7.85		1.70	1026.30	Yes	No	No
Aero/No Upset	3.40		6.90	4.90	8.45	50	7.65		2.00	1141.45	Yes	No	No
Aero/No Upset	4.00		4.60	4.80							No	Yes - 6.15	Yes
No Aero/Upset	5.15		7.40	4.90	15.65	50	7.00		2.18	1580.07	Yes	No	No
No Aero/Upset	2.75		3.90	4.45	10.35	0	3.95		1.44	1077.88	Yes	No	No
No Aero/Upset	4.75		5.20	5.05	9.30	20	5.50	21.25	2.08	1507.54	Yes	No	No
No Aero/Upset	2.80		8.25	8.30		65	8.25	8.25	2.61	1652.46	Yes	Yes - 10.90	No

[119] Measured from when bank angle exceeded five degrees.
[120] Stabilized flight within the normal flight envelop for transport category aircraft.
[121] Data missing due to computer failure during flight during flight.
[122] Data missing due to cable break in wheel column that occurred during flight.

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Aileron Input (sec)[119]	Time to Correct Rudder Input (sec)	Time to Correct Throttle Input (sec)	Delta from 210 Corner Speed (KIAS)	Time to Correct Elevator Input (sec)	Time to Trim Input (sec)	Maximum Normal Acceleration (g)	Altitude Lost (ft)	Recovered[120]	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
No Aero/Upset	0.40		4.75	3.55		10	4.55		1.81	398.69	Yes	No	No
No Aero/Upset	1.60		5.30	4.95	10.90	50	6.25		1.67	735.46	Yes	No	No
No Aero/Upset[123]													
No Aero/Upset[124]													
Aero/Upset	6.05		5.30	4.90	9.55	40	6.55		1.88	1935.21	Yes	No	No
Aero/Upset			5.45	3.00	12.15	30	6.85		1.72	1051.94	Yes	No	No
Aero/Upset	3.95		5.00	4.85						1360.30	No	Yes - 9.30	Yes
Aero/Upset	9.95		7.60	7.75	28.35	65	7.60		2.54	2196.33	Yes	No	No
Aero/Upset	3.90		4.65	4.85	28.95	20	6.10		1.59	859.37	Yes	No	No
Aero/Upset	2.50		3.85	6.30		50	6.90	18.50	1.95	1104.56	Yes	No	No
Aero/Upset	3.10		3.70	2.65		10	2.65		1.65	310.49	Yes	No	No
Aero/Upset[125]													
In-flight	4.15		5.15	8.45	19.15	40	7.15		2.19	768.61	Yes	No	No
In-flight	4.60	14.35	7.35	4.95		120	7.65		2.74	2996.91	No	Yes - 14.55	No
In-flight	3.15	8.75	5.95	5.50			5.90		2.56	1073.17	Yes	Yes - 8.60	Yes
In-flight	5.20		6.95	4.95		50	7.00		2.42	1088.61	Yes	No	No
In-flight	3.75	20.60	5.35	5.05		35	5.60		2.13	809.93	Yes	No	No
In-flight	3.70		3.70	3.30	12.20	20	4.80		1.53	459.47	Yes	No	No
In-flight	2.95		6.60	19.05	8.95	15	6.50		2.49	1202.29	Yes	No	No
In-flight	4.95	16.55	7.10	7.35		90	7.10		2.97	2288.05	No	Yes - 16.45	No

[123] Data missing due to computer failure during flight.
[124] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[125] Data missing due to severe thunderstorms that required use of ground simulation mode only.

Table 40. Group Mean and Standard Deviation for Performance Data for Toledo

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Throttle Input (sec)	Delta from 210 K Corner Speed (KIAS	Time to Correct Elevator Input (sec)	Time to Emergency Trim Input (sec)	Maximum Normal Acceleration (g)	Altitude Lost (ft)	Recovered	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
No Aero/No Upset													
Mean	3.050	7.85	3.900	4.000	13.960	35.000	5.820	7.600	1.971	772.238	6 out of 6	2 out of 6	0 out of 6
Standard Deviation	1.675		0.608	0.737	8.884	21.213	1.455		0.373	384.227			
N	6	1	6	8	6	7	7	1	7	7			
Aero/No Upset													
Mean	3.631		5.188	5.331	17.908	47.857	6.779		2.118	1093.369	6 out of 8	2 out of 8	2 out of 8
Standard Deviation	1.080		1.458	1.901	9.395	31.867	1.955		0.609	877.850			
N	8		7	7	4	6	6		6	7			
No Aero/Upset													
Mean	2.908		5.800	5.200	11.550	32.500	5.917	14.750	1.966	1158.683	6 out of 6	2 out of 6	1 out of 6
Standard Deviation	1.814		1.666	1.617	2.813	26.029	1.590	9.192	0.417	511.141			
N	6		8	8	3	7	8	2	8	8			
Aero/Upset													
Mean	4.908		5.079	4.900	19.750	35.833	6.108	18.500	1.888	1259.743	6 out of 7	2 out of 7	1 out of 7
Standard Deviation	2.747		1.300	1.768	10.334	20.104	1.764		0.348	641.899			
N	6		6	6	5	5	5	1	5	5			
In-flight													
Mean	4.056	12.050	6.019	7.325	13.433	52.857	6.463		2.378	1335.880	6 out of 8	2 out of 8	1 out of 9
Standard Deviation	0.817	4.941	1.238	4.996	5.211	38.499	0.956		0.439	860.246			
N	8	4	8	6	4	6	6		6	6			

Table 41. Group Mean and Standard Deviation for Recovery Data for Toledo[126]

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Throttle Input (sec)	Delta from 210 K Corner Speed (KIAS)	Time to Correct Elevator Input (sec)	Time to Emergency Trim Input (sec)	Maximum Normal Acceleration (g)	Altitude Lost (ft)	Safety Trip - Yes (sec)	Safety Trip Affect Recovery
Recovery												
Mean	3.718	12.400	5.133	5.414	[illegible]	34.643	[illegible]	13.900	[illegible]	[illegible]	[illegible]	4 yes 25 no
Standard Deviation	1.812	7.116	1.322	3.013	8.02	18.999	1.380	7.000	0.348	499.039		
N	28	3	29	29	22	28	29	4	29	29	29	29
No Recovery												
Mean	3.767	15.450	5.758	5.526	[illegible]	106.667	[illegible]		[illegible]	[illegible]	[illegible]	3 yes 3 no
Standard Deviation	1.306	1.556	1.912	2.167		15.275	1.455		0.351	732.374		
N	6	2	6	6	0	3	3	0	3	4	6	6

[126] Shading indicates significant difference.

Two sets of analyses were performed – those to evaluate the effects of different types of training and those to identify differences in performance between evaluation pilots who recovered and those who did not. Each of these is discussed in a separate section below.

5.3.2.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.2.1.1 Announce problem

The first variable of interest was time to announce the problem. There was no significant effect of training on this variable ($F (4, 29) = 1.439$, $p = 0.246$). Ironically the No Aero/No Upset and the No Aero/Upset group means were nearly identical although only the second group would have been trained to announce a problem.

5.3.2.1.2 Crosscheck instruments

No quantitative data were available to measure this step in the recovery procedure.

5.3.2.1.3 Disconnect autopilot

Only five evaluation pilots used the master disconnect. One was from the No Aero/No Upset group with relatively high flight hours (3200). The other four were from the in-flight group. Since so few evaluation pilots made this response an anova was not calculated by training group.

5.3.2.1.4 Aggressively roll right to approximately wings level

There was no significant effect on time to correct aileron input ($F (4, 30) = 2.580$, $p = 0.057$). While amplitude of roll was not analyzed, a lack of sufficient roll input was indicative of considerable altitude loss or lack of recovery and was incorporated in to the safety pilot rating.

5.3.2.1.5 Use rudder to enhance roll rate

There was no significant effect on time to correct rudder input ($F (4, 30) = 1.386$, $p = 0.262$).

5.3.2.1.6 Retard power to remain near corner speed

There was no significant effect of training group on time to correct throttle input ($F (4, 17) = 0.714$, $p = 0.594$). Also of interest was the evaluation pilot's ability to maneuver around the aircraft's corner speed (as briefed 210 knots) since this is a key component in aircraft recovery and all airplane upset recovery training. Again, the effect of training group was not significant ($F (4, 26) = 0.608$, $p = 0.661$).

5.3.2.1.7 Full aft column and nose-up trim to 2.5 g pull up

There was no significant effect of training group on time to first correct elevator input ($F (4, 27) = 0.412$, $p = 0.799$). Use of emergency trim has also been included in

airplane upset training, however, only four evaluation pilots used this feature – one from No Aero/No Upset, one from No Aero/Upset, and two from No Aero/Upset.

Accident data have repeatedly shown that evaluation pilots usually must make significant initial inputs to recover the aircraft at the onset of an upset. There, maximum acceleration was of interest in evaluating the types of training. Yet again, there was no significant effect of training ($F (4, 27) = 1.297$, $p = 0.296$) although pilots are told to pull the maximum g of the airplane in an upset recovery if needed. For most transport–category aircraft the normal g limit is 2.5 gs. In the case of the Lear, the g safety limit was 2.8 to allow an evaluation of the recovery technique. Data show that although trained, the evaluation pilots were reluctant to pull beyond 2 gs in a real airplane. In addition, this upset started at between 1300 and 1500 feet AGL and therefore altitude loss was critical.

5.3.2.1.8 Maintain climb until 1500 AGL

Again there was no significant effect of training group on this variable ($F (4, 28) = 0.542$, $p = 0.706$).

5.3.2.1.9 Safety trips and comments

Finally, there was concern that the safety trips in the Lear would affect recovery performance. Although safety trips did occur, none of them affected whether the evaluation pilots recovered the aircraft but only how quickly they recovered since safety trips occurred whenever the evaluation pilot either made no input or an incorrect input (in either control or amplitude). Since the safety trips occurred after the evaluation pilot inputs, the safety pilot was able to assess whether recovery was possible.

A description of each airplane-upset recovery is presented in Table 42. As can be seen from the comments, there were large variations in recovery performance from taking control early to very late, from alerting the captain to watch altitude to not being clear on what was going on, and from taking control decisively to not taking control at all. The most common errors were intervening too late and not pulling enough positive g (which coincide with the actual accident scenario's outcome).

Table 42. Comments on Airplane Upset Recovery Performance Data for Toledo

Group	Recovered	Safety Trip - Yes (sec)	Safety Trip Affect Recovery	Comments
No Aero/No Upset	Yes	No	No	SP took control of aircraft after event complete. Little bit of negative G in recovery. Asked for max power. No vision restrictors.
No Aero/No Upset	Yes	Yes - 7.75	Yes	Trip on AOA and Nz. EP took control after computer "beep[127]" but SP believed VSS tripped itself, not EP.
No Aero/No Upset	Yes	No	No	EP recovered holding right aileron, left wing down. EP called he had control just before computer "beep".
No Aero/No Upset	Yes	No	No	Good recovery. EP took control prior to computer "beep."
No Aero/No Upset	No	Yes - 4.85	Yes	EP took control early in upset after calling to "watch your altitude" then "watch your bank." EP was starting to take control prior to computer "beep." Good intervention.

[127] Up to the beep any EP control input was summed with the Captain's control input. After the beep, only the EP's control input was effective.

Group	Recovered	Safety Trip - Yes (sec)	Safety Trip Affect Recovery	Comments
No Aero/No Upset	Yes	No	No	EP called bank angle and took control early (before beep). Good recovery.
Aero/No Upset	Yes	No	No	None.
Aero/No Upset	Yes	No	No	SP took control of aircraft after event complete.
Aero/No Upset	No	Yes - 18.50	No	EP said it "wasn't clear" what was going on. SP took control in dive. A/C went negative G then positive G.
Aero/No Upset	Yes	No	No	Called "bank angle." Took control after SP asked, "you got it?" EP inadvertently pushed auto recover button on yoke.
Aero/No Upset	Yes	Yes - 22.80	No	EP called "bank angle," added power and recovered aircraft. SP took control after recovery.
Aero/No Upset	Yes	No	No	EP recovered with airspeed ~ 280 KIAS.
Aero/No Upset	Yes	No	No	EP called over bank. EP took control after EP asked, "You got it?" EP recovered at 260 KIAS.
Aero/No Upset	No	Yes - 6.15	Yes	VSS trip on deltaAs and deltaPr during recovery. Good call on bank angles.
No Aero/Upset	Yes	No	No	None
No Aero/Upset	Yes	No	No	None
No Aero/Upset	Yes	No	No	EP called bank angle. EP pulled power back and asked for help with controls. Good recovery.
No Aero/Upset	Yes	Yes - 10.90	No	EP called bank angle but didn't take control early enough. SP took control at ~120 deg of bank with nose down.
No Aero/Upset	Yes	No	No	EP took control decisively at the computer "beep" call after calling "sink rate." EP rolled quickly to wings level and only had to pull gently for good recovery.
No Aero/Upset	Yes	No	No	EP took control decisively with "I got it" at the computer "beep" call after calling "steep turn." EP applied max power and recovered.
Aero/Upset	Yes	No	No	Repeat. EP may have known what was coming after having seen the initial characteristics of the maneuver in Rec 5 (VSS trip)
Aero/Upset	Yes	No	No	EP reduced thrust but didn't pull too hard. Lowest altitude was 200 ft AGL. SP took control after event complete.
Aero/Upset	No	Yes - 9.30	Yes	EP called out "bank angle." Good bewildered look and "you got it?" from SP. EP responded with "No." SP took control in dive.
Aero/Upset	Yes	No	No	SP asked if EP had it. EP responded that he didn't. EP did eventually take control and recovered with 200 ft altitude clearance, 280 KIAS. Pulled some positive G but could have pulled more.
Aero/Upset	Yes	No	No	EP called over bank. Cleared terrain by 1000 ft. Good recovery but could have pulled harder.
Aero/Upset	Yes	No	No	EP called to check bank. EP took control, added power and recovered.
Aero/Upset	Yes	No	No	EP called bank angle and "my airplane" very early. EP called for max power.
In-flight	Yes	No	No	EP called bank angle and took control after beep and after SP asked "You got it?". Good recovery pulling positive G.
In-flight	No	Yes - 14.55	No	Very late intervention by EP. EP didn't pull enough Nz. SP took control in dive.
In-flight	Yes	Yes - 8.60	Yes	EP called "hardover" and "Need help with controls?" before intervening late. VSS trip on -Nz and AOA.
In-flight	Yes	No	No	EP took control after computer "beep" and EP questioning "You've got it?" Recovered but intervened a little late.
In-flight	Yes	No	No	EP called bank angle then said he/she was helping with controls. Told SP to release controls. EP took control at ~90 deg phi. Good recovery although could have jumped on controls sooner.
In-flight	Yes	No	No	EP intervened quickly (before computer "beep"), said

Group	Recovered	Safety Trip - Yes (sec)	Safety Trip Affect Recovery	Comments
				"whoa, my controls", called for max power, and recovered.
In-flight	Yes	No	No	EP mentioned bank angle but took control a little late. EP said that he/she had control. EP pulled power back, used rudder to help roll, and pulled Nz to recover.
In-flight	No	Yes - 16.45	No	EP intervened late after EP commented "whoa!" SP took control in dive. EP didn't pull enough Nz.

5.3.2.2 Recovery Differences

Analyses were also calculated to compare performance of evaluation pilots who recovered with those who did not. There was no significant difference in time to announce the problem ($F(1, 32) = 0.004$, $p = 0.951$) or to press the master disconnect ($F(1, 3) = 0.323$, $p = 0.610$) or to make any of the control inputs (aileron $F(1, 33) = 0.955$, $p = 0.336$); rudder $F(1, 33) = 0.026$, $p = 0.872$) except throttle. Twenty-two of the 30 evaluation pilots who recovered put in correct throttle inputs. None of the five evaluation pilots who did not recover made any correct throttle inputs. In addition, 28 of the 30 evaluation pilots who recovered from the Toledo evaluation scenario maintained significantly smaller deltas from the corner speed than evaluation pilots who did not recover ($F(1, 29) = 39.913$, $p = 0.000$). These evaluation pilots also made correct elevator inputs faster than evaluation pilots who did not recover ($F(1, 30) = 6.473$, $p = 0.016$). However, only 4 of the evaluation pilots who recovered used emergency trim while none of the evaluation pilots who did not recover used it. Elevator trim enabled these evaluation pilots to more easily pull g. The evaluation pilots who recovered had pulled significantly lower gs than evaluation pilots who did not recover ($F(1, 30) = 24.986$, $p = 0.000$) and lost significantly less altitude ($F(1, 31) = 24.157$, $p = 0.000$).

There was also a significant relationship between recovery and safety trip ($\chi^2(1) = 18.103$, $p < 0.001$). All of the evaluation pilots, who did not recover, had safety trips. Only 4 of the 29 evaluation pilots who recovered had safety trips. However, the relationship between recovery and safety trips affecting that recovery was also significant ($\chi^2(1) = 4.073$, $p < 0.050$). Evaluation pilots who recovery were less likely to have safety trips that affected their recovery than pilots who did not recover. Safety trips that occurred were AOA (>10 or < 5 degrees; typical of airplane upset accidents), Nz (> 2.8 or < 0.15 g), aileron stick force (> 45 lbs), and rudder pedal force (> 208 pounds).

5.3.3 Shemya

This accident occurred during cruise in which an inadvertent deployment of the leading edge wing slats. The correct recovery performance and the variables used to quantify that performance (see Table 43) were:

1. Announce problem (e.g., "autopilot's acting strange").
   a. Time to announce problem
2. Depress master disconnect button.
   a. Time to disconnect autopilot
   b. Time to correct aileron input
3. Recognize PIO tendency.
4. Back out of pitch control loop to avoid coupling.
   a. Time to correct elevator input

5. Use low pitch control gains.
    a. Low pitch gain
    b. Time to stick shaker
6. Use low frequency pitch inputs.
    a. Max Nz
7. Use lead compensation in pitch.
    a. Min Nz
8. Don't chase altitude.
    a. Chase altitude
9. Trim to near 1 g flight.
    a. Time to correct trim input
10. Investigate source of problem.
11. Cautiously release master disconnect button.
    a. Time to master disconnect
12. Inform ATC of problem/altitude deviation.
13. Descend to lower altitude.

Step 2 disconnects the autopilot and in most transport airplanes interrupts the trim system. Step 11 would enable normal trim if it were available. Between these steps, the evaluation pilot attempts to isolate the problem while controlling the aircraft. This scenario while requiring totally different piloting technique, reflects a part of standard airplane upset training and was therefore included as an evaluation scenario. This is not a difficult scenario to recover from if the autopilot is disconnected early and the amplitude of the evaluation pilot inputs is small.

The ultimate test of training is the ability to recover from an airplane upset. Only four evaluation pilots (i.e., 11%) recovered from the Shemya accident scenario (1 in No Aero/No Upset, Aero/No Upset, Aero/Upset, and In-flight). Three of these evaluation pilots disconnected the autopilot very quickly (0.0, 3.7, and 6.3 seconds). One, however, did not (25.1 seconds). The most common error made by evaluation pilots who did not recover this scenario was not turning off the autopilot prior to making a large control input. In addition, those who did recover were very light on the control inputs since they were having to deal with a very large pitch transient coupled with undesirable flying qualities. In this scenario correct recovery procedures call for "recognizing the problem and backing out of the control loop" – much different than any of the other scenarios.

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.3). A summary of the recovery data is presented in Table 43. Means and standard deviations by group are presented in Table 44. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and those who did not. Means and standard deviations by recovery outcome are presented in Table 45. Values that are significantly different are shaded.

Table 43. Performance Data for Shemya

Group	Time to Announce Problem (sec)	Time to Disconnect Autopilot (sec)	Time to Correct Aileron Input (sec)	Time to Correct Elevator Input	Low Pitch Gain	Chase altitude	Time to Correct Trim Input (sec)	Time to Master Disconnect (sec)	Max Nz	Min Nz	Time to Stick Shaker (sec)	Recovered[128]	Safety Trip – Yes (sec)	Safety Trip Affect Recovery
No Aero/No Upset	10	8.00		8.05	No				1.72	0.08	8.00	No	49.35	Yes
No Aero/No Upset	1			7.40	No				1.67	0.10	7.55	No	43.75	Yes
No Aero/No Upset	6	7.35		7.60	No				1.47	-0.09	8.10	No	53.05	Yes
No Aero/No Upset		8.55		8.60	No			9.35	2.10	-0.11	8.00	No	43.50	Yes
No Aero/No Upset	4	5.50		4.85	No				1.83	0.12	4.55	No	43.35	Yes
No Aero/No Upset		4.90		5.00	No				2.42	0.16	4.45	No	36.35	Yes
No Aero/No Upset		0.00	0.75	3.00	Yes	Yes	6.80		1.60	0.50		Yes	80.85	No
No Aero/No Upset	5	3.85	4.20	3.90	No		5.10		1.76	-0.09		No	28.1	Yes
Aero/No Upset	8	8.40		8.55	No				2.42	-0.28	7.90	No	55.65	Yes
Aero/No Upset	5	1.65	2.40	7.15	No			6.95	1.43	0.03		No	45.35	Yes
Aero/No Upset	3	3.15	3.90	4.80	No				1.48	-0.05		No	36.60	Yes
Aero/No Upset		0.85	0.80	4.50	No				1.78	0.19	4.75	No	45.15	Yes
Aero/No Upset	1			3.80	No				1.57	-0.14		No	38.35	Yes
Aero/No Upset		4.00		4.35	No			5.20	1.35	0.15		No	41.30	Yes
Aero/No Upset		4.40		4.60	No		5.40		2.21	0.21	4.20	No	44.70	Yes
Aero/No Upset	3	3.75	1.85	4.00	Yes	No		7.85	2.06	0.34	4.10	Yes	66.35	No
No Aero/Upset	2	8.85		7.70	No				1.52	-0.03	7.80	No	50.00	Yes

[128] Stabilized flight within the normal flight envelop for transport category aircraft.

Group	Time to Announce Problem (sec)	Time to Disconnect Autopilot (sec)	Time to Correct Aileron Input (sec)	Time to Correct Elevator Input	Low Pitch Gain	Chase altitude	Time to Correct Trim Input (sec)	Time to Master Disconnect (sec)	Max Nz	Min Nz	Time to Stick Shaker (sec)	Recovered[128]	Safety Trip – Yes (sec)	Safety Trip Affect Recovery
No Aero/Upset		7.45		7.85	No				1.51	-0.08	8.05	No	55.25	Yes
No Aero/Upset		4.85		4.90	No				2.20	-0.20	4.45	No	44.55	Yes
No Aero/Upset	6		6.05	5.20	No				2.31	0.02	4.50	No	45.35	Yes
No Aero/Upset	7	4.55		4.65	No				2.19	-0.12	4.40	No	38.35	Yes
No Aero/Upset	4	6.40		5.40	No				2.16	-0.07	4.90	No	34.25	Yes
No Aero/Upset[129]														
No Aero/Upset[130]														
Aero/Upset	2	6.30	5.70	6.85	Yes	No			1.31	0.61		Yes	95.90	No
Aero/Upset		4.50		4.75	No				1.84	-0.06	4.50	No	47.00	Yes
Aero/Upset		4.95		4.60	No				1.83	0.03	4.45	No	40.10	Yes
Aero/Upset		5.45		5.50							4.45	No	39.60	Yes
Aero/Upset			5.05	4.35	No		1.10		1.90	0.39	4.20	No	33.45	Yes
Aero/Upset	6	5.05		4.80	No			5.35	2.45	0.00	4.40	No	51.80	Yes
Aero/Upset		4.40		4.55	No		5.65		1.93	-0.14	4.45	No	39.55	Yes
Aero/Upset[131]														
In-flight	4			3.90	No				1.52	-0.03	4.20	No	39.95	Yes
In-flight		6.80		5.70	No				2.28	-0.13	4.80	No	53.90	Yes
In-flight	5	5.10		5.00	No				2.39	0.64	4.35	No	37.70	Yes
In-flight	3	4.50		4.35	No			5.40	1.59	-0.02	4.55	No	48.60	Yes
In-flight	7			4.75	No			5.00	2.06	0.20	4.50	No	39.20	Yes
In-flight	1	25.10	1.70	3.45	Yes	No			1.61	0.46	6.00	Yes	55.85	No
In-flight	4	4.25		4.10	No				1.74	-0.02	4.05	No	32.25	Yes

[129] Data missing due to computer failure during flight.
[130] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[131] Data missing due to severe thunderstorms that required use of ground simulation mode only.

Group	Time to Announce Problem (sec)	Time to Disconnect Autopilot (sec)	Time to Correct Aileron Input (sec)	Time to Correct Elevator Input	Low Pitch Gain	Chase altitude	Time to Correct Trim Input (sec)	Time to Master Disconnect (sec)	Max Nz	Min Nz	Time to Stick Shaker (sec)	Recovered[129]	Safety Trip – Yes (sec)	Safety Trip Affect Recovery
In-flight[132]														

[132] Data missing due to wheel column breaking during flight.

Table 44. Group Mean and Standard Deviation for Performance Data for Shemya

Group	Time to Announce Problem (sec)	Time to Disconnect Autopilot (sec)	Time to 5 degree bank	Time to Correct Aileron Input (sec)	Time to Correct Elevator Input	Low Pitch Gain	Chase altitude	Time to Correct Trim Input (sec)	Time to Master Disconnect (sec)	Max Nz	Min Nz	Time to Stick Shaker (sec)	Recovered	Safety Trip – Yes (sec)	Safety Trip Affect Recovery
No Aero/No Upset															
Mean	5.350	5.450	2.119	2.475	6.050	1 out of 8	1 out of 8	5.950	9.350	1.821	0.084	[redacted]	1 out of 8	47.288	7 out of 8
Standard Deviation	3.221	2.952	0.136	2.440	2.111			1.202		0.304	0.199	1.773		15.557	
N	5	7	8	2	8	8		2	1	8	8	6		8	
Aero/No Upset															
Mean	3.960	3.743	2.081	2.238	5.219	1 out of 8		5.400	6.667	1.788	0.056	5.238	1 out of 8	46.681	7 out of 8
Standard Deviation	2.814	2.425	0.113	1.292	1.697				1.348	0.399	0.205	1.798		9.822	
N	5	7	8	4	8	8		1	3	8	8	4		8	
No Aero/Upset															
Mean	4.638	6.420	2.058	6.050	5.950	0 out of 6		3.375		1.982	-0.080	5.683	0 out of 6	44.625	6 out of 6
Standard Deviation	1.951	1.798	0.097		1.437			3.217		0.365	0.076	1.747		7.607	
N	4	5	6	1	6	6		2	0	6	6	6		6	
Aero/Upset															
Mean	4.100	5.108	2.014	5.375	5.057	1 out of 7			5.350	1.877	0.139	[redacted]	1 out of 7	49.629	6 out of 7
Standard Deviation	2.475	0.698	0.144	0.460	0.870					0.362	0.294	0.107		21.242	
	2	6	7	2	7	7		0	1	6	6	6		7	
In-flight															
Mean	4.067	9.150	2.193	1.700	4.464	1 out of 7			5.200	1.884	0.157	4.636	1 out of 7	43.921	6 out of 7
Standard Deviation	1.930	8.972	0.117		0.752				0.283	0.356	0.291	0.649		8.914	
N	6	5	7	1	7	7		0	2	7	7	7		7	

Table 45. Group Mean and Standard Deviation for Recovery Data for Shemya[133]

Group	Time to Announce Problem (sec)	Time to Disconnect Autopilot (sec)	Time to 5 degree bank	Time to Correct Aileron Input (sec)	Time to Correct Elevator Input	Low Pitch Gain	Chase altitude	Time to Correct Trim Input (sec)	Time to Master Disconnect (sec)	Max Nz	Min Nz	Time to Stick Shaker (sec)	Safety Trip – Yes (sec)	Safety Trip Affect Recovery
Recovery														
Mean	1.002	8.788	2.113	2.500	4.325	[illegible]	1 yes 3 no	6.800	7.850	[illegible]	0.478	5.050	[illegible]	32 yes 0 no
Standard Deviation	2.283	11.179	0.155	2.188	1.732					0.310	0.111	1.344	17.438	
N	3	4	4	4	4	4	4	1	1	4	4	2	4	32
No Recovery														
Mean	4.782	5.296	2.092	3.733	5.475	[illegible]		4.310	6.210	[illegible]	0.021	5.352	[illegible]	0 yes 4 no
Standard Deviation	2.330	1.991	0.130	1.883	1.483			2.1504	1.690	0.341	0.181	1.557	6.924	
N	19	26	32	6	32	31			6	31	31	27	32	0

[133] Shading indicates significant difference.

Two sets of analyses were performed – those to evaluate the effects of different types of training and those to identify differences in performance between evaluation pilots who recovered and those who did not. Each of these is discussed in a separate section below.

5.3.3.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.3.1.1 Announce problem (e.g., "autopilot's acting strange")

The first dependent variable of interest was the time to announce the problem. There was no significant difference between groups ($F(4, 17) = 0.253$, $p = 0.904$) and 14 of the evaluation pilots did not announce the problem throughout the entire evaluation scenario. The majority was from the Aero/Upset group where 5 out of 7 said nothing. One (In-flight), two (No Aero/Upset), or three (No Aero/No Upset and Aero/No Upset) did not announce the problem in the other groups.

5.3.3.1.2 Depress master disconnect button

The dependent variable of interest for this step in the recovery procedure was the time to disconnect the autopilot. Again, the difference between groups was not significant ($F(4, 25) = 1.344$, $p = 0.282$). The second variable of interest was time to first correct aileron input. Only 10 of the 36 evaluation pilots made a correct aileron input (2 in No Aero/No Upset, 4 in Aero/No Upset, 1 in No Aero/Upset, 2 in Aero/Upset, and 1 in In-flight).

5.3.3.1.3 Recognize PIO tendency

No quantitative data were available to measure this step in the recovery procedure.

5.3.3.1.4 Back out of pitch control loop to avoid coupling

All evaluation pilots did respond with elevator input. However, there was no significant difference between groups ($F(4, 31) = 1.371$, $p = 0.267$).

5.3.3.1.5 Use low pitch control gains

Very few evaluation pilots used low pitch gains (1 out of 8 in No Aero/No Upset and Aero/No Upset groups, 0 out of 6 in No Aero/Upset group, and 1 out of 7 in Aero/Upset and In-flight groups). Also one evaluation pilot (Aero/Upset group) did not make any pitch input (which ironically, in this case, was beneficial to smoother aircraft response).

The stick shaker warning did not occur for 7 of the evaluation pilots since they were not able to control the aircraft long enough after the initial event for the shaker to occur (2 in No Aero/No Upset, 4 in Aero/No Upset, 1 in Aero/Upset). For the remaining evaluation pilots, there was a significant difference between groups ($F(4, 24) = 3.021$, $p = 0.038$). A Scheffé post hoc test indicated only one significant difference – evaluation

pilots in the Aero/Upset encountered the stick shaker significantly sooner than the No Aero/No Upset group.

5.3.3.1.6 *Use low frequency pitch inputs*

Airplane upset recovery training normally stresses the need for max control inputs. Therefore, max acceleration was of interest. However, there were no significant differences among training groups in maximum Nz ($F(4, 30) = 0.290$, $p = 0.882$).

5.3.3.1.7 *Use lag compensation in pitch.*

Minimum accelerations were of interest in this step of the recovery procedure. There were no significant differences among groups in minimum Nz ($F(4, 30) = 1.062$, $p = 0.393$).

5.3.3.1.8 *Don't chase altitude*

Most evaluation pilots were not able to control the aircraft long enough to assess if they were chasing the altitude. For those four evaluation pilots who were able, one chased the altitude (No Aero/No Upset) while the other 3 did not (Aero/No Upset, Aero/Upset, and In-flight).

5.3.3.1.9 *Trim to near 1 g flight*

Only five evaluation pilots made trim inputs (2 No Aero/No Upset, 1 Aero/No Upset, and 2 No Aero/Upset).

5.3.3.1.10 *Investigate source of problem*

No quantitative data were available to measure this step in the recovery procedure.

5.3.3.1.11 *Cautiously release master disconnect button*

Only 7 evaluation pilots used the master disconnect (1 in No Aero/No Upset, 3 in Aero/No Upset, 1 in Aero/Upset, and 2 In-flight). As in the actual accident scenario, had the automation been disconnected before attempting a recovery, the initial input required would have been significantly smaller.

5.3.3.1.12 *Inform ATC of problem/altitude deviation*

None of the evaluation pilots informed ATC of either a problem or an altitude deviation.

5.3.3.1.13 *Descend to lower altitude*

None of the evaluation pilots descended to a lower altitude.

5.3.3.1.14 *Safety trips and comments*

All evaluation pilots encountered the safety trip due to the severity of the pitch up in this accident scenario. However, there was no significant difference in the time at which the different groups encountered the safety trip ($F4, 31) = 0.188$, $p = 0.943$). The safety trip affected all but four of the evaluation pilots' ability to recover (see Table 46). Failure to disconnect the autopilot early enough resulted in a large amplitude pitch excursion that triggered a safety trip. This failure to recognize the problem and take

control early in effect precluded the ability to evaluate recovery technique beyond initial inputs.

Table 46. Comments on Airplane Upset Recovery Performance Data for Shemya

Group	Recovered	Safety Trip - Yes (sec)	Safety Trip Affect Recovery	Comments
No Aero/No Upset	No	49.35	Yes	VSS trip on Nz and ST-1.
No Aero/No Upset	No	43.75	Yes	VSS trip on Nz. Large amplitude pitch up.
No Aero/No Upset	No	53.05	Yes	VSS trip on AOA and Nz. Pitch up amplitude seemed about right. EP was pushing when VSS tripped. EP thought he or she pushed AP disconnect before pushing.
No Aero/No Upset	No	43.50	Yes	VSS trip on Nz during push over. Pitch up amplitude seemed about right.
No Aero/No Upset	No	43.35	Yes	Two pitch cycles before VSS trip on Nz.
No Aero/No Upset	No	36.35	Yes	SP took control before too much negative G. EP pulled power after disengaging autopilot.
No Aero/No Upset	Yes	80.85	No	Excellent recovery. EP was very light on controls after disconnecting autopilot. No demonstration required.
No Aero/No Upset	No	28.1	Yes	VSS trip on -Nz. stick_shaker_alpha_setting = 10.0 deg.
Aero/No Upset	No	55.65	Yes	VSS trip on Nz.
Aero/No Upset	No	45.35	Yes	VSS trip on Nz.
Aero/No Upset	No	36.60	Yes	EP pushed AP disconnect during roll upset. Tried to maneuver in roll with no effect because EP control was still locked out. When EP finally got roll control, EP ended up with a roll PIO before VSS tripped during pitch up. VSS tripped on das, AOA, Nz.
Aero/No Upset	No	45.15	Yes	VSS trip on Nz.
Aero/No Upset	No	38.35	Yes	EP pushed on wheel before VSS tripped on negative Nz.
Aero/No Upset	No	41.30	Yes	VSS trip on negative Nz.
Aero/No Upset	No	44.70	Yes	SP took control as EP was making negative G input.
Aero/No Upset	Yes	66.35	No	EP disconnected AP immediately. EP flew with very light control forces to recover from upset. VSS did not trip. No demo required.
No Aero/Upset	No	50.00	Yes	VSS trip on AOA and Nz
No Aero/Upset	No	55.25	Yes	VSS trip on Nz.
No Aero/Upset	No	44.55	Yes	Big negative G. VSS trip on Nz and AOA.
No Aero/Upset	No	45.35	Yes	VSS trip on -Nz.
No Aero/Upset	No	38.35	Yes	VSS trip on -Nz and AOA. EP called to set max power during pitch up.
No Aero/Upset	No	34.25	Yes	VSS trip on -Nz and AOA. EP clicked autopilot off while pushing on yoke.
No Aero/Upset				
No Aero/Upset				
Aero/Upset	Yes	95.90	No	Good Maneuver (40K' displayed instead of 39K').
Aero/Upset	No	47.00	Yes	EP pushed AP disconnect. SP took control just as aircraft going nose down. AOA trip prior to SP taking control.

Group	Recovered	Safety Trip - Yes (sec)	Safety Trip Affect Recovery	Comments
Aero/Upset	No	40.10	Yes	VSS trip on negative Nz.
Aero/Upset	No	39.60	Yes	VSS trip on AOA due to large amplitude pitch up caused by VSS. EP never got on the controls. EP did not push autopilot disconnect.
Aero/Upset	No	33.45	Yes	VSS trip on negative Nz.
Aero/Upset	No	51.80	Yes	VSS trip on -Nz.
Aero/Upset	No	39.55	Yes	VSS trip on -Nz.
Aero/Upset				
In-flight	No	39.95	Yes	VSS trip on -Nz. EP did not disengage AP.
In-flight	No	53.90	Yes	VSS trip on -Nz and AOA.
In-flight	No	37.70	Yes	EP disconnected autopilot before pushing on yoke. SP took control prior to big -Nz.
In-flight	No	48.60	Yes	VSS trip on -Nz after EP had significant force on yoke prior to disconnecting autopilot.
In-flight	No	39.20	Yes	VSS trip on -Nz. EP called "trim runaway."
In-flight	Yes	55.85	No	EP used light hand flying to recover. EP disconnected autopilot at roll upset. Very nice recovery.
In-flight	No	32.25	Yes	VSS trip on -Nz. EP disconnected autopilot while pushing on yoke.
In-flight				

5.3.3.2 Recovery Differences

In addition to evaluating the effects of training, comparisons were also made between evaluation pilots who recovered and those who did not. There were no significant differences between these two groups in the time to announce the problem ($F(1, 20) = 3.244$, $p = 0.087$) or to disconnect the autopilot ($F(1, 28) = 2.496$, $p = 0.125$). Nor were there any differences between the groups in time to critical control inputs (5 degree bank $F(1, 34) = 0.083$, $p = 0.774$; correct aileron input $F(1, 8) = 0.910$, $p = 0.386$; correct elevator input $F(1, 34) = 2.071$, $p = 0.159$; or stick shaker ($F(1, 27) = 0.071$, $p = 0.792$). Nor was there a significant difference in max Nz ($F(1, 33) = 1.879$, $p = 0.180$). However, evaluation pilots who recovered did so with a higher Min Nz (0.478g) than those who did not (0.021g) Min Nz ($F(1, 33) = 23.778$, $p = 0.000$).

Further, there was a significant difference in maintaining a low pitch gain between the evaluation pilots who recovered (all four were able to maintain a low pitch gain) and those who did not (none of the 31 were able to maintain a low pitch gain). Data on whether the evaluation pilot chased the altitude were available only for the four evaluation pilots who recovered. One of these did chase the altitude; the other 3 did not. Although there was not sufficient data to perform an anova, evaluation pilots who recovered may have input the correct trim response and disconnected the autopilot later than the evaluation pilots who did not recover.

There was a significant difference in time to a safety trip between the evaluation pilots who recovered (74.938 sec) and the evaluation pilots who did not (42.981 seconds) ($F(1, 34) = 50.827$, $p = 0.000$). Further in every case, evaluation pilots who hit the safety trip did not recover and evaluation pilots who did not hit the safety trip did. This is to be expected given the very large control inputs associated with the Shemya evaluation scenario. The majority of safety trips were on Nz (> 2.8 g). Several evaluation pilots went through two pitch cycles before encountering a safety trip.

Completion of the steps as presented was sufficient to recover the aircraft in all evaluation scenarios. Due to the differences in these scenarios, timing, amplitude, and sequence may have differed. In all cases pilot control alone was sufficient to recover the aircraft (if done correctly). Other steps would facilitate recovery or could in some cases replace control input.

5.3.4 Nagoya

This accident occurred during an ILS approach in which the aircraft began a steep pitch up. The scenario began with the safety pilot giving the aircraft to the evaluation pilot to make an approach. At a consistent point in the approach, the flight test engineer activated the VSS computer to initiate the programmed pitch runaway. The correct recovery performance and the variables used to quantify that performance (see Table 47) were:

1. Announce problem.
   a. Time to announce problem
2. Depress master disconnect button.
   a. Time to master disconnect
3. Use full nose down column.
   a. Time to correct elevator input
   b. Wheel full forward
4. Roll the aircraft to reduce the vertical component of the lift vector and prevent the aircraft from climbing too steeply. Actively adjust bank angle to control flight path angle.
   a. Time to correct aileron input
5. Airspeed should be kept low to reduce the gs and the consequent bank angle required to maintain level flightpath.
   a. Airspeed at emergency
   b. Minimum airspeed
   c. Airspeed delta
6. Call for emergency nose down trim.
   a. Time to call emergency trim input
7. Investigate source of problem.
8. Cautiously release master disconnect button.
   a. Call to investigate source of problem
9. Inform ATC of problem/altitude deviation/inability to hold heading.
   a. Time to inform ATC of inability to hold altitude or heading

Twelve out of 36 pilots (i.e., 33%) recovered from the Nagoya scenario (3 out of 8 No Aero/No Upset, 2 out of 8 Aero/No Upset, 3 out of 8 No Aero/Upset, 1 out of 7 Aero/Upset, and 3 out of 7 In-flight group). All but one evaluation pilot recovered using only emergency trim. That one evaluation pilot used roll in addition to emergency trim to recover the aircraft. The most common mistake among evaluation pilots who did not recover was not using bank angle to change the direction of the lift vector this resulted in the aircraft stalling in a nose-high attitude. Only 23 of the 36 pilots used roll.

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.4). A summary of the recovery data is presented in Table 47. Means and standard deviations by group are presented in Table 48. The recovery data for the surprise scenario are presented in Table 49 and the associated means and standard deviations in Table 50. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and evaluation pilots who did not. Means and standard deviations by recovery outcome are presented in Table 51. Values that are significantly different are shaded.

Table 47. Performance Data for Nagoya

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Elevator Input (sec)	Wheel Full Forward	Time to Correct Aileron Input (sec)	Airspeed at Emergency (KIAS)	Minimum Airspeed (KIAS)	Airspeed Delta (KIAS)	Time to Call for Emergency Trim (sec)	Time to Emergency Trim Input (sec)	Call to Investigate Source of Problem	Time to Inform ATC of Inability to Hold Altitude or Heading (sec)	Recovered [134]	Safety Trip – Yes (sec)
No Aero/No Upset	5.65		1.257	Yes	7.21	156.8	130.3	26.5					No	
No Aero/No Upset	8.2	22.95	3.755	Yes		156.2	134.1	22.1	29.2				No	
No Aero/No Upset	11.95		2.103	Yes		157.6	125.4	32.2	14.95	18.85			Yes	
No Aero/No Upset	3.45	7.65	2.633	Yes	23.237	163.7	120.3	43.4					No	
No Aero/No Upset	8.2		2.96	Yes	11.91	155.3	131.5	23.8				19.2	No	
No Aero/No Upset	9		3.206	Yes		154.1	110.9	43.2					No	AOA
No Aero/No Upset	9.65	7.3	2.45	Yes		157.2	124.3	32.9	11.65	13.65			Yes	
No Aero/No Upset	7.75	7.9	1.7561	Yes	15.349	154	134.1	19.9	9.75	12.5			Yes	
Aero/No Upset	3.45		1.62	Yes	18.499	153.3	123.6	29.7					No	AOA
Aero/No Upset	6.45	6.85	1.7317	Yes *		149.4	115.2	34.2	11.45	14.05			Yes	
Aero/No Upset	10.1		2.62	Yes*		151.8	142.6	9.2					No	AOA
Aero/No Upset	16.4		4.34	Yes	0.193	157.8	120.2	37.6					No	
Aero/No Upset	9.35	23.35	3.26	Yes		165.7	114.3	51.4					No	AOA

[134] Stabilized flight within the normal flight envelop for transport category aircraft.

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Elevator Input (sec)	Wheel Full Forward	Time to Correct Aileron Input (sec)	Airspeed at Emergency (KIAS)	Minimum Airspeed (KIAS)	Airspeed Delta (KIAS)	Time to Call for Emergency Trim (sec)	Time to Emergency Trim Input (sec)	Call to Investigate Source of Problem	Time to Inform ATC of Inability to Hold Altitude or Heading (sec)	Recovered [134]	Safety Trip – Yes (sec)
Aero/No Upset	7.25		3.725	Yes		156.5	116.1	40.4					No	
Aero/No Upset	8.7		1.82	Yes		152.3	128.7	23.6	16.7				No	AOA
Aero/No Upset	12.4	24.65	3.49	Yes	30.775	155.1	112.5	42.6					Yes	
No Aero/Upset	4.55	12.3	1.56	Yes	18.2865	153.4	150.8	2.6					No	AOA
No Aero/Upset			1.72	Yes		153.1	137.7	15.4					No	AOA
No Aero/Upset	6.1		3.519	Yes		170.8	162.8	8	7.1	10.6			Yes	
No Aero/Upset	4.7		1.41	Yes		168.3	157.1	11.2	4.7	6.45			Yes	
No Aero/Upset			2.5862	Yes*		154	129.3	24.7					No	AOA
No Aero/Upset	6.45	16.9522	3.571	Yes		158.9	101.7	57.2	15.45	18.85		53.45	Yes	
No Aero/Upset [135]														
No Aero/Upset [136]														
Aero/Upset	6.25		1.837	Yes		167.3	149.6	17.7					No	
Aero/Upset	12.85		3.64	Yes	7.71	147.5	120.6	26.9					No	AOA
Aero/Upset	12.95	12.5	3.736	Yes	30.54	153.9	124.8	29.1					No	AOA
Aero/Upset	13.6		3.6545	Yes		162	119.7	42.3					No	AOA
Aero/Upset	9.15	36.95	3.13	Yes		155.2	123.6	31.6					No	
Aero/Upset			4.655	Yes	22.6445	156.3	112.1	44.2					No	AOA
Aero/Upset	8.3	8.75	2.098	Yes	12.6245	155.9	138.3	17.6	10.3	15.3			Yes	

[135] Data missing due to computer failure during flight.
[136] Data missing due to severe thunderstorms that required use of ground simulation mode only.

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Elevator Input (sec)	Wheel Full Forward	Time to Correct Aileron Input (sec)	Airspeed at Emergency (KIAS)	Minimum Airspeed (KIAS)	Airspeed Delta (KIAS)	Time to Call for Emergency Trim (sec)	Time to Emergency Trim Input (sec)	Call to Investigate Source of Problem	Time to Inform ATC of Inability to Hold Altitude or Heading (sec)	Recovered [134]	Safety Trip – Yes (sec)
Aero/Upset [137]														
In-flight	7.65	13.1	1.912	Yes	11.4513	155.8	131.8	24					No	AOA
In-flight	14.2	13.9	4.038	Yes		160.5	142.5	18	14.2				No	AOA
In-flight	6.8		4.33	Yes	9.7982	153.8	134.7	19.1					No	AOA
In-flight	7.2	14.05	3.1284	Yes	14.341	153.6	143.3	10.3	13.2	26.2			Yes	
In-flight			2.9535	No	3.5396	140.95	146.9	-5.95					No	AOA
In-flight	6.2		3.414	Yes		166.8	152.3	14.5	6.2	11.55			Yes	
In-flight	6.95		3.5343	Yes	16.3224	160.8	140.7	20.1	9.95	10.7			Yes	
In-flight [138]														

[137] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[138] Data missing due to wheel column breaking during flight.

Table 48. Group Mean and Standard Deviation for Performance Data for Nagoya[139]

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Elevator Input (sec)	Wheel Full Forward	Time to Correct Aileron Input (sec)	Airspeed at Emergency (KIAS)	Minimum Airspeed (KIAS)	Airspeed Delta (KIAS)	Time to Call for Emergency Trim (sec)	Time to Emergency Trim Input (sec)	Call to Investigate Source of Problem	Time to Inform ATC of Inability to Hold Altitude or Heading (sec)	Recovered	Safety Trip – Yes (sec)
No Aero/No Upset														
Mean	8.014	11.450	2.515	8 out of 8	14.427	156.863	126.363	30.500	16.388	15.000	0 out of 8	0 out of 8	3 out of 8	1 out of 8
Standard Deviation	2.758	7.671	0.807		6.755	3.073	7.952	9.104	8.808	3.383				
N	7	4	8		4	8	8	8	4	3				
Aero/No Upset														
Mean	8.814	18.283	2.826	8 out of 8	16.489	155.238	[redacted]	[redacted]	14.075	14.050	0 out of 8	0 out of 8	2 out of 8	4 out of 8
Standard Deviation	4.006	9.923	1.031		15.390	5.013	10.033	12.934	3.712					
N	7	3	8		3	8	8	8	2	1				
No Aero/Upset														
Mean	5.450	14.626	2.394	6 out of 6	18.287	159.750	139.900	19.850	9.083	11.967	0 out of 6	0 out of 6	3 out of 6	3 out of 6
Standard Deviation	0.965	3.290	0.980			7.919	22.430	19.754	5.643	6.312				
N	4	2	6		1	6	6	6	3	3				
Aero/Upset														
Mean	10.517	19.400	3.250	7 out of 7	18.380	156.871	126.957	29.914	10.300	15.300	0 out of 7	0 out of 7	1 out of 7	4 out of 7
Standard Deviation	3.028	15.314	0.989		10.215	6.269	12.722	10.574						
N	6	3	7		4	7	7	7	1	1				
In-flight														
Mean	8.167	13.683	3.330	6 out of 7	11.091	156.036	[redacted]	[redacted]	10.888	16.150	0 out of 7	0 out of 7	3 out of 7	4 out of 7
Standard Deviation	2.994	0.511	0.790		4.918	8.135	6.959	9.921	3.613	8.714				
N	6	3	7		5	7	7	7	4	3				

139 Shading indicates significant difference.

Table 49. Performance Data for Nagoya Surprise

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Elevator Input (sec)	Wheel Full Forward	Time to Correct Aileron Input (sec)	Airspeed at Emergency (KIAS)	Minimum Airspeed (KIAS)	Airspeed Delta (KIAS)	Time to Call for Emergency Trim (sec)	Time to Emergency Trim Input (sec)	Call to Investigate Source of Problem	Time to Inform ATC of Inability to Hold Altitude or Heading (sec)	Recovered[140]	Safety Trip – Yes (sec)
No Aero/No Upset	6.05	24.35	2.07	Yes		179.4	139.2	40.2					No	
Aero/No Upset	14.25	13.75	2.68	Yes		204	132.8	71.2	18.25	23.05			Yes	
Aero/No Upset	5.7		1.86	Yes		196.3	134.8	61.5					No	AOA
Aero/No Upset	11.5		2.7495	Yes		183.4	125.1	58.3	11.5	13.9			Yes	AOA
Aero/No Upset	7.85	12.65	2.749	Yes	14.827	197.5	166.1	31.4					Yes	AOA
No Aero/Upset	7.1		1.673	Yes	9.398	208.5	164.4	44.1					No	
Aero/Upset	7.6		1.996	Yes		195	156.8	38.2					No	AOA
Aero/Upset	10.4	16.4	2.54	Yes		193	135.2	57.8					No	
In-flight	8		2.546	Yes		188.1	137.7	50.4					No	SP
In-flight	9.65		2.135	Yes	8.914	217.5	188.3	29.2	17.65	17.4			Yes	
In-flight	5.4		1.9934	No		189.65	171.6	18.05					No	AOA

[140] Stabilized flight within the normal flight envelop for transport category aircraft.

Table 50. Group Mean and Standard Deviation for Performance Data for Nagoya Surprise

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Elevator Input (sec)	Wheel Full Forward	Time to Correct Aileron Input (sec)	Airspeed at Emergency (KIAS)	Minimum Airspeed (KIAS)	Airspeed Delta (KIAS)	Time to Call for Emergency Trim (sec)	Time to Emergency Trim Input (sec)	Call to Investigate Source of Problem	Time to Inform ATC of Inability to Hold Altitude or Heading (sec)	Recovered	Safety Trip – Yes (sec)
No Aero/No Upset														
Mean	6.05	24.35	2.070	1 out of 1		179.400	139.200	40.200			0 out of 1	0 out of 1	0 out of 1	0 out of 1
Standard Deviation														
Aero/No Upset														
Mean	9.825	13.2	2.510	4 out of 4	14.827	195.300	139.700	55.600	14.875	18.475	0 out of 4	0 out of 4	3 out of 4	3 AOA out of 4
Standard Deviation	3.799	0.778	0.434			8.624	18.090	17.040	4.773	6.470				
No Aero/Upset														
Mean	7.1		1.673	1 out of 1	9.398	208.500	164.400	44.100			0 out of 1	0 out of 1	0 out of 1	0 out of 1
Standard Deviation														
Aero/Upset														
Mean	9	16.4	2.268	2 out of 2		194.000	146.000	48.000			0 out of 2	0 out of 2	0 out of 2	1 AOA out of 2
Standard Deviation	1.980		0.385			1.414	15.275	13.860						
In-flight														
Mean	7.683		2.225	2 out of 3	8.914	198.417	165.867	32.550	17.650	17.400	0 out of 3	0 out of 3	1 out of 3	1 Sp and 1 AOA out of 3
Standard Deviation	2.143		0.287			16.545	25.783	16.433						

Table 51. Group Mean and Standard Deviation for Recovery Data for Nagoya[141]

Group	Time to Announce Problem (sec)	Time to Master Disconnect (sec)	Time to Correct Elevator Input (sec)	Wheel Full Forward	Time to Correct Aileron Input (sec)	Airspeed at Emergency (KIAS)	Minimum Airspeed (KIAS)	Airspeed Delta (KIAS)	Time to Call for Emergency Trim (sec)	Time to Emergency Trim Input (sec)	Call to Investigate Source of Problem	Time to Inform ATC of Inability to Hold Altitude or Heading (sec)	Safety Trip – Yes (sec)
Recovery													
Mean	7.842	12.350	2.684	12 yes 0 no	17.882	159.033	133.975	25.058	[illegible]	14.427	0 yes 12 no	53.45	[illegible]
Standard Deviation	2.371	6.632	0.837		7.336	6.510	18.769	14.942	3.440	5.324			
N	12	7	12	12	5	12	12	12	11	11	12	1	12
No Recovery													
Mean	8.888	17.838	2.956	23 yes 1 no	13.752	155.719	129.029	26.690	[illegible]	0 yes 24 no	0 yes 24 no	12.19	[illegible]
Standard Deviation	3.597	9.432	0.999		8.973	5.557	11.646	13.834	8.036				
N	20	8	24	24	12	24	24	24	3	24	24	1	24

[141] Shading indicates significant difference.

Two sets of analyses were performed – those to evaluate the effects of different types of training and those to identify differences in performance between evaluation pilots who recovered and evaluation pilots who did not. Each of these is discussed in a separate section below.

5.3.4.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.4.1.1 Announce problem

The variable of interest was time to announce the problem. There was no significant difference in this variable between groups ($F (4, 25) = 1.706$, $p = 0.180$).

5.3.4.1.2 Depress master disconnect button

The variable was the time to disconnect the autopilot. Less than half of the evaluation pilots disconnected the autopilot (4 out of 8 in No Aero/No Upset, 3 out of 8 in Aero/No Upset, 2 out of 6 in No Aero/Upset, 3 out of 7 in Aero/Upset and in In-flight). For the evaluation pilots who did disconnect the autopilot, there was no significant effect of group ($F (4, 10) = 0.425$, $p = 0.787$).

5.3.4.1.3 Use full nose down column

There were no significant differences between groups in time to make the correct elevator input ($F (4, 31) = 1.430$, $p = 0.247$). Also all but one evaluation pilot moved the wheel full forward. The one who did not was in the In-flight group.

5.3.4.1.4 Roll the aircraft to reduce the vertical component of the lift vector and prevent the aircraft from climbing too steeply. Actively adjust bank angle to control flight path angle.

There were no significant difference among the five training groups in time to make the first correct aileron input ($F (4, 12) = 0.414$, $p = 0.795$).

5.3.4.1.5 Airspeed should be kept low to reduce the gs and the consequent bank angle required to maintain level flightpath.

There was no significant difference among training groups in airspeed at emergency trim ($F4, 31) = 0.495$, $p = 0.740$). There was, however, a significant effect of group on minimum airspeed ($F (4, 31) = 3.565$, $p = 0.017$). The highest minimum airspeed (good) occurred in the In-flight group and the lowest (bad) in the Aero/No Upset group. A Scheffé post hoc analysis was calculated. There were no other significant differences between groups. There was also a significant difference between groups in the change in airspeed during the recovery ($F (4, 31) = 2.990$, $p = 0.034$). The smallest change was for the In-flight group and the largest for the Aero/No Upset group. Again a Scheffé post hoc analysis indicated that this was the only significant difference between groups.

5.3.4.1.6 *Call for emergency nose down trim*

There were no significant differences in time to call for emergency trim ($F (4, 9) = 0.745$, $p = 0.585$). Less than one third of the evaluation pilots input emergency trim (3 out of 8 in the No Aero/No Upset group, 1 out of 8 in the Aero/No Upset group, 3 out of 6 in the No Aero/Upset group, 1 out of 7 in the Aero/Upset group, and 3 out of 7 in the In-flight group). Given the low number, an anova was not calculated for this variable.

5.3.4.1.7 *Investigate source of problem*

None of the evaluation pilots called to investigate the source of the problem.

5.3.4.1.8 *Cautiously release master disconnect button*

None of the evaluation pilots released the master disconnect button.

5.3.4.1.9 *Inform ATC of problem/altitude deviation/inability to hold heading*

None of the evaluation pilots called ATC to report inability to hold altitude and/or heading.

5.3.4.1.10 *Safety trips and comments*

Angle of attack safety trip occurred in less than half of the recoveries (1 out of 8 in the No Aero/No Upset group, 4 out of 8 in the Aero/No Upset group, 3 out of 8 in the No Aero/Upset group, 4 out of 7 in the Aero/Upset and In-flight groups). The safety trip did not affect any of the evaluation pilots' ability to recover since it occurred long after the evaluation pilot's recovery inputs had been or have been made (see Table 52). One evaluation pilot had experienced a real life runaway trim within the last year. Another mistook the scenario for wake turbulence that he or she also experienced in the last year.

Table 52. Comments on Airplane Upset Recovery Performance Data for Nagoya

Group	Method	Recovered	Safety Trip – Yes (sec)	Comments
No Aero/No Upset		No		SP took control with nose high.
No Aero/No Upset		No		SP took control with nose high.
No Aero/No Upset	Emer Trim	Yes		None.
No Aero/No Upset		No		SP took control with nose high.
No Aero/No Upset		No		SP took control with nose high (AOA = 10+ deg & increasing). EP not feeling well.
No Aero/No Upset		No	AOA	None
No Aero/No Upset	Emer Trim	Yes		None
No Aero/No Upset	Emer Trim	Yes		None
Aero/No Upset		No	AOA	"Rolled to get out of wake vortex." Bank Angle ~ 20 deg.
Aero/No Upset	Emer Trim	Yes		None
Aero/No Upset		No	AOA	EP let up on wheel force just before VSS trip (70 lb to 15 lb)

Group	Method	Recovered	Safety Trip – Yes (sec)	Comments
Aero/No Upset		No		EP very active in roll. SP took control with nose high (AOA = 9+ deg & increasing)
Aero/No Upset		No	AOA	None
Aero/No Upset		No		SP took control with nose high (AOA = 9+ deg & increasing)
Aero/No Upset		No	AOA	EP called for Emer Trim just as VSS tripped
Aero/No Upset	Roll	Yes		None
No Aero/Upset		No	AOA	EP banked left only after SP prompt just before VSS trip
No Aero/Upset		No	AOA	None
No Aero/Upset	Emer Trim	Yes		EP had real-life runaway trim within last year
No Aero/Upset	Emer Trim	Yes		None
No Aero/Upset		No	AOA	None
No Aero/Upset	Emer Trim	Yes		None
No Aero/Upset				
No Aero/Upset				
Aero/Upset		No		SP took control with nose high (AOA = 9+ deg)
Aero/Upset		No	AOA	None
Aero/Upset		No	AOA	EP thought about rolling but didn't.
Aero/Upset		No	AOA	None
Aero/Upset		No		SP took control with nose high (AOA = 9+ deg & increasing)
Aero/Upset		No	AOA	None
Aero/Upset	Emer Trim	Yes		None
Aero/Upset				
In-flight		No	AOA	None
In-flight		No	AOA	None
In-flight		No	AOA	None
In-flight	Roll & Emer Trim	Yes		None
In-flight		No	AOA	Pitch up seemed too quick
In-flight	Emer Trim	Yes		None
In-flight	Emer Trim & Roll	Yes		None
In-flight				

5.3.4.2 Recovery Differences

In subsequent analyses, the performance of evaluation pilots who recovered from the Nagoya evaluation scenario was compared to that of evaluation pilots who did not recover. There was no significant difference in time to announce the problem ($F(1, 30) = 0.800$, $p = 0.378$), master disconnect ($F(1, 13) = 1.648$, $p = 0.222$), correct elevator input

(F (1, 34) = 0.658, p = 0.423), correct aileron input (F (1, 15) = 0.820, p = 0.379), or call for emergency trim (F (1, 12) = 10.545, p = 0.007). Nor were airspeeds at emergency onset (F (1, 34) = 2.540, p = 0.120), minimum airspeed (F (1, 34) = 0.951, p = 0.336), or change in airspeed (F (1, 34) = 0.106, p = 0.747) significantly different.

In addition there were no significant differences between the evaluation pilots who recovered and the evaluation pilots who did not in frequency of placing the wheel full forward (χ^2 (1) = 0.514, p $\leq$ 1.000). However, 12 out of 24 evaluation pilots who recovered used emergency trim while only 1 out of 11 evaluation pilots who did not recover used it (χ^2 (1) = 31.68, p = 0.001). This difference was significant. But none of the evaluation pilots, either those who recovered or those who did not, called to investigate the source of the problem. Further only one evaluation pilot in each group notified ATC of his or her inability to hold altitude or heading.

For the recovery method, 9 evaluation pilots used emergency trim, 2 emergency trim and roll, and 1 roll only. AOA safety trips were encountered by 16 of the 24 evaluation pilots who did not recover. No safety trips occurred for the evaluation pilots who recovered. This difference was significant (χ^2 (1) = 14.400, p = 0.001). However, the safety trips did not affect the evaluation pilots' ability to recover since the safety pilot took control with the nose high on all of the unsuccessful recovery attempts with the evaluation pilot making no inputs to recover.

5.3.5 Charlotte

This accident occurred during final approach in windshear conditions. The correct recovery performance and the variables used to quantify that performance (see Table 53) were:

1. Announce problem.
   a. Time to announce problem
2. Maximum thrust.
   a. Time to definitive thrust change
3. Disconnect autopilot.
   a. Time to autopilot disconnect
4. Leave gear and flaps unchanged.
   a. Flaps/gear changed
5. Rotate to 15° pitch attitude.
   a. Time to correct elevator input
   b. Time to attain 15 degrees theta
6. Accept low airspeed.
   a. Accept low airspeed
7. Use near stick shaker angle of attack.
   a. Time to first stick shaker activation
8. Do not lower nose in an attempt to increase airspeed.
   a. Lower nose for airspeed
   b. Time to reach 500 ft/min
   c. Altitude lost

Only one evaluation pilot did not recover (defined as a return to stabilized flight within the normal flight envelop for transport category aircraft) from the Charlotte scenario (i.e., 97% of the evaluation pilots recovered). The evaluation pilot was in the In-flight group and may have been unable to recover due to a safety trip. Given the very high percentage of evaluation pilots who were able to recover from this scenario, evaluation pilots were asked after the flight if they had received windshear recovery training. All evaluation pilots had received windshear training that typically consisted of simulator exercises performed to criterion, i.e., three recoveries in a row. The training was usually bundled with the engine out on takeoff recoveries and was highly practiced.

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.5). A summary of the recovery data is presented in Table 53. Note that the variables in the table were derived from the correct recovery procedure presented above. Means and standard deviations by group are presented in Table 54. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and those who did not. Means and standard deviations by recovery outcome are presented in Table 55. Values that are significantly different are shaded.

Table 53. Performance Data for Charlotte

Group	Time to Announce Problem (sec)	Time to Definitive Thrust Change (sec)	Time to Autopilot Disconnect (sec)	Flaps/ gear changed (Yes/No)	Time to Correct Elevator Input (sec)	Time to Attain 15 degrees Theta (sec)	Accept low airspeed (Yes/No)	Time to First Stick Shaker Activation (sec)	Percent Time Stick Shaker Activated	Lower nose for airspeed (Yes/No)	Time to Reach 500 ft/min (sec)	Altitude lost (feet)	Recovered [142]	Safety Trip Affect Recovery
No Aero/No Upset	0.15	2.1		No	2.25	9.45	Yes	1.9	95.17	No	7.25	86	Yes	No
No Aero/No Upset	5.55	5.15		Yes	0		No	1.95	90.18	No	13.15	237	Yes	No
No Aero/No Upset	3.95	2.65		No	1.15	17.1	Yes	1.9	94.04	No	12.6	148	Yes	No
No Aero/No Upset	-22.8	2.25		Yes	0.25	6.45	Yes	1.95	88.04	Yes	0	0	Yes	No
No Aero/No Upset	11.35	3.15		Yes			Yes	1.9	94.2	No	16.65	150	Yes	No
No Aero/No Upset	-18.05			No		4.8	Yes	4	58.69	No	0.55	0	Yes	No
No Aero/No Upset	4.65	2		Yes			No	1.95	89.06	No	11.35	136	Yes	No
No Aero/No Upset														
Aero/No Upset	-0.9			No		6.6	Yes		100	No	0.3	0	Yes	No
Aero/No Upset	1.9	2.65		Yes	0.15		Yes	1.95	92.19	No	8.05	68	Yes	No
Aero/No Upset	3.7	2.65		Yes	0		No	1.85	65.72	Yes	44.7	228	Yes	No
Aero/No Upset	7.7	3.8		Yes		22.2	Yes	1.95	31.26	No	11.6	221	Yes	No
Aero/No Upset	14.35	2.4		No		10	Yes	1.95	86.83	No	6.8	32.48	Yes	No
Aero/No Upset	-12.95	3.35		Yes			No	1.9	93.37	Yes	17.85	242.4	Yes	No
Aero/No Upset	7.25	4.3		No			No	1.95	60.31	No	11.05	157.4	Yes	No
Aero/No Upset	1.9	3.9		Yes			No	2.45	85.97	No	16.35	166	Yes	No
No	2.15	2.25		Yes			Yes	0.05	99.8	No	5.8	53	Yes	No

[142] Stabilized flight within the normal flight envelop for transport category aircraft.

Group	Time to Announce Problem (sec)	Time to Definitive Thrust Change (sec)	Time to Autopilot Disconnect (sec)	Flaps/ gear changed (Yes/No)	Time to Correct Elevator Input (sec)	Time to Attain 15 degrees Theta (sec)	Accept low airspeed (Yes/No)	Time to First Stick Shaker Activation (sec)	Percent Time Stick Shaker Activated	Lower nose for airspeed (Yes/No)	Time to Reach 500 ft/min (sec)	Altitude lost (feet)	Recovered [142]	Safety Trip Affect Recovery
Aero/Upset														
No Aero/Upset		4.6		No	4.25		No	2.35	40.93	No	11.75	100	Yes	No
No Aero/Upset	2.45	3.35		Yes			Yes	2.8	90.19	No	5.55	10	Yes	No
No Aero/Upset	8.75	2.9		No	2.6	9.35	Yes	1.9	92.15	No	5.35	41	Yes	No
No Aero/Upset		4.1					Yes	1.95	71.31	Yes	5.8	35.9	Yes	No
No Aero/Upset	2.15	3.65		No		23.15	Yes	2.95	87.78	No	5.05	91	Yes	No
No Aero/Upset	2.05	2.75		No		18.3	Yes	1.95	92.87	No	4.35	31	Yes	No
No Aero/Upset [143]														
No Aero/Upset [144]	3	2		Yes			No	0.4	44.12	No	12	125	Yes	No
Aero/Upset	1.8	2		No	1.85		Yes	1.95	94.38	No	6.25	55	Yes	No
Aero/Upset	2.45	4.75		No			Yes	1.95	93.24	No	11.65	216	Yes	No
Aero/Upset	3.85	3.6		No			Yes	1.95	94.77	No	6.5	145.7	Yes	No
Aero/Upset	4.95	7.45		No			No	1.95	89.95	No	12.8	144.8	Yes	No
Aero/Upset	4.9	3.7		Yes			No	1.95	75.62	Yes	8.75	200	Yes	No
Aero/Upset	3	2.05		Yes		8.35	Yes	1.95	88.04	No	4.1	25	Yes	No
Aero/Upset [145]														
In-flight	2	2.55		Yes	2.45		No	1.95	89.3	No	10.55	138	Yes	No
In-flight		2.2		No			Yes	1.9	37.72	No	3.2	58	No	Yes

[143] Data missing due to computer failure during flight.
[144] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[145] Data missing due to severe thunderstorms that required use of ground simulation mode only.

Group	Time to Announce Problem (sec)	Time to Definitive Thrust Change (sec)	Time to Autopilot Disconnect (sec)	Flaps/ gear changed (Yes/No)	Time to Correct Elevator Input (sec)	Time to Attain 15 degrees Theta (sec)	Accept low airspeed (Yes/No)	Time to First Stick Shaker Activation (sec)	Percent Time Stick Shaker Activated	Lower nose for airspeed (Yes/No)	Time to Reach 500 ft/min (sec)	Altitude lost (feet)	Recovered [142]	Safety Trip Affect Recovery
In-flight	-2.25	6.1		No		23.6	Yes	1.9	93.21	No	9.4	59	Yes	No
In-flight	2	4.45		No		9.95	Yes	1.95	92.2	No	6.2	102	Yes	No
In-flight	2.5	3.3		No	2.8	7.5	Yes	1.95	89.71	Yes	4.75	49	Yes	No
In-flight	7.35	3.4		No		12.35	Yes	1.9	92.32	No	8.45	40	Yes	No
In-flight	1.95	3.55		Yes			Yes	4.1	36.88	No	7.05	122	Yes	No
In-flight[146]														

[146] Data missing due to wheel column breaking during flight.

Table 54. Group Mean and Standard Deviation for Performance Data for Charlotte[147]

Group	Time to Announce Problem (sec)	Time to Definitive Thrust Change (sec)	Time to Autopilot Disconnect (sec)	Flaps/ gear changed (Yes/No)	Time to Correct Elevator Input (sec)	Time to Attain 15 degrees Theta (sec)	Accept low airspeed (Yes/No)	Time to First Stick Shaker Activation (sec)	Percent Time Stick Shaker Activated	Lower nose for airspeed (Yes/No)	Time to Reach 500 ft/min (sec)	Altitude lost (feet)	Recover	Safety Trip Affect Recovery
No Aero/No Upset														
Mean	-2.171	2.883	0 out of 7	4 out of 7	0.913	9.450	5 out of 7	2.221	87.054	1 out of 7	8.793	108.143	7 out of 7	0 out of 7
Standard Deviation	12.971	1.188			1.019	5.451		0.785	12.813		6.447	86.218		
N	7	6			4	4		7	7		7	7		
Aero/No Upset														
Mean	2.869	3.293	0 out of 8	5 out of 8	[illegible]	12.933	4 out of 7	2.000	76.956	2 out of 8	14.588	139.410	8 out of 8	0 out of 8
Standard Deviation	7.940	0.738			0.106	8.203		0.202	22.999		13.360	94.197		
N	8	7			2	3		7	8		8	8		
No Aero/Upset														
Mean	3.510	3.371	0 out of 7	2 out of 7	[illegible]	16.933	6 out of 7	1.993	82.147	1 out of 7	6.236	51.700	7 out of 7	0 out of 7
Standard Deviation	2.933	0.815			1.167	7.001		0.956	20.163		2.483	32.687		
N	5	7			2	3		7	7		7	7		
Aero/Upset														
Mean	3.421	3.650	0 out of 7	1 out of 7	1.850	8.350	4 out of 7	1.729	82.874	1 out of 7	8.864	130.214	7 out of 7	0 out of 7
Standard Deviation	1.200	1.986						0.586	18.315		3.372	70.043		
	7	7			1	1		7	7		7	7		
In-flight														
Mean	2.258	3.650	0 out of 7	2 out of 7	2.625	13.350	6 out of 7	2.236	75.906	1 out of 7	7.086	81.143	6 out of 7	1 out of 7
Standard Deviation	3.051	1.301			0.247	7.114		0.822	26.412		2.600	38.921		
N	6	7			2	4		7	7		7	7		

[147] Shading indicates significant difference.

Table 55. Group Mean and Standard Deviation for Recovery Data for Charlotte

Group	Time to Announce Problem (sec)	Time to Definitive Thrust Change (sec)	Time to Autopilot Disconnect (sec)	Flaps/ gear changed (Yes/No)	Time to Correct Elevator Input (sec)	Time to Attain 15 degrees Theta (sec)	Accept low airspeed (Yes/No)	Time to First Stick Shaker Activation (sec)	Percent Time Stick Shaker Activated	Lower nose for airspeed (Yes/No)	Time to Reach 500 ft/min (sec)	Altitude lost (feet)	Safety Trip Affect Recovery
Recovery													
Mean	1.903	3.420		16 yes 18 no	1.614	12.610	11 yes 24 no	2.040	82.109	7 yes 28 no	9.439	104.448	0 yes 35 no
Standard Deviation	7.276	1.240			1.411	6.490		0.712	18.796		7.541	72.220	
N	35	35	35	34	11	15	35	34	35	35	35	35	
No Recovery													
Mean		2.200		1 no			1 yes	1.900	37.720	1 no	3.200	55.000	1 yes
Standard Deviation													
N	1	1	1	1			1	1	1	1	1	1	1

Two sets of analyses were performed – those to evaluate the effects of different types of training and those to identify differences in performance between evaluation pilots who recovered and the evaluation pilots who did not. Each of these is discussed in a separate section below.

5.3.5.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.5.1.1 Announce problem

There was no significant effect of training group on time to announce the problem ($F(4, 28) = 0.697$, $p = 0.600$). Note that several evaluation pilots announced the problem prior to the onset of the windshear. Their announcement was based solely on the script heard to that point. The negative response time in Table 54 was a result of anticipation. At the very beginning of this scenario, this particular pilot discussed the windshear escape procedure with the safety pilot. The pilot was obviously "on-guard" for any type of windshear cue. The level of injected turbulence was increased as the aircraft proceeded down the glideslope on final approach. At or near minimums the flaps were brought up to give a sinking feeling and the displayed airspeed was rolled off via computer command. The audio data for this record indicates a pilot comment about "having a stick shaker" two seconds before the "start" of the event. The start of the event for Charlotte was defined as the time at which the displayed airspeed rate of change was 10 KIAS/sec. This could happen if the pilot reacted quickly to the flap change by pulling aft on the yoke prior to the displayed airspeed rolling off.

5.3.5.1.2 Maximum thrust

There were no significant effects of training group on time to definitive thrust change ($F(4, 29) = 0.385$, $p = 0.818$).

5.3.5.1.3 Disconnect autopilot

None of the evaluation pilots disconnected the autopilot. This was surprising since the groups who had received upset training were taught to disconnect the autopilot immediately at the onset of any airplane upset. This failure may demonstrate the importance of repetitive practice in addition to lecture and demonstration.

5.3.5.1.4 Leave gear and flaps unchanged

In addition, several of the evaluation pilots did change flap or gear settings and should not have (4 out of 7 in the No Aero/No Upset group, 5 out of 8 in the Aero/No Upset group, 2 out of 7 in the No Aero/Upset and In-flight groups, and 3 out of 7 in the Aero/Upset group).

5.3.5.1.5 Rotate to 15° pitch attitude

There was a significant difference between groups in the time to correct elevator input prior to attaining 15 degrees theta ($F(4, 6) = 5.065$, $p = 0.040$). A Scheffé post hoc analysis indicated that only the two extreme groups were significantly different (Aero/No Upset = 0.075 and No Aero/Upset = 3.425). However, not all the evaluation pilots made

correct elevator inputs prior to attaining 15 degrees theta (4 out of 7 in the No Aero/No Upset group, 2 out of 8 in the Aero/No Upset group, 2 out of 7 in the No Aero/Upset and In-flight groups, and 1 out of 7 in the Aero/Upset group). The numbers indicate the number of evaluation pilots who made correct elevator inputs prior to attaining 15 degrees theta out of the total number of evaluation pilots for whom there are data. There was, however, no significant difference in time to attain 15 degrees of pitch attitude ($F(4, 10) = 0.616$, $p = 0.661$).

5.3.5.1.6 Accept low airspeed

Most of the evaluation pilots accepted a slow airspeed (5 out of 7 in the No Aero/No Upset group, 4 out of 7 in the Aero/No Upset and the Aero/Upset groups, 6 out of 7 in the No Aero/Upset and In-flight groups).

5.3.5.1.7 Use near stick shaker angle of attack

There were no significant differences between groups in time to first stick shaker activation ($F(4, 30) = 0.581$, $p = 0.679$) or in percent time on the stick shaker ($F(4, 31) = 0.350$, $p = 0.842$).

5.3.5.1.8 Do not lower nose in an attempt to increase airspeed

Very few evaluation pilots lowered the nose for airspeed (1 out of 7 in No Aero/No Upset, No Aero/Upset, Aero/Upset, and In-flight groups and 2 out of 8 in Aero/No Upset group). There was no significant difference between groups in time to reach 500 feet per minute ($F(4, 31) = 1.54$, $p = 0.215$) or in altitude lost during the recovery ($F(4, 31) = 1.929$, $p = 0.130$). Note that time cannot be used as an absolute criterion across all aircraft since some aircraft respond more quickly than others. The important criterion is to stay on the edge of the stick shaker.

5.3.5.1.9 Safety trips and comments

As stated previously, only one safety trip occurred and it did indeed affect the evaluation pilot's ability to recover. There were extensive comments both during and after the flight regarding these recoveries. These comments are presented in Table 56. Evaluation pilots fell into two groups – those who aggressively pulled and those who hesitated. Small airspeed increases were not uncommon nor were departures from the stick shaker.

Table 56. Comments on Airplane Upset Recovery Performance Data for Charlotte

Group	FTE Comments	Data Analyst Comments
No Aero/No Upset	None	Thrust was high then pulled back right before event start. Aircraft was flying level -- constant altitude before event start.
No Aero/No Upset	No Windshear call from SP. SP took control after event complete.	Evaluation pilot pushed nose down, pitch attitude decreased, aircraft descended in altitude and increased airspeed after slight initial climb. One minute after event, a consistent positive climb rate was attained.
No Aero/No Upset	EP recovered from upset. EP commented that it "was more realistic than the simulator" during debrief. Roll oscillations on climb out due to over control.	Good recovery - definitive, authoritative pitch up and climb out. Short time slice - less than 20 seconds from event start until VSS down mode.
No Aero/No Upset	Approach. SP thought FTE meant to give the windshear right now. Therefore, ended up with windshear event during initial stages of go-around.	Evaluation pilot pulled aggressively getting pitch attitude up and climbing quickly. Good recovery.

Group	FTE Comments	Data Analyst Comments
No Aero/No Upset	Event marker was late. No windshear call from SP. Good recovery.	Thrust pushed up to 1500 lb initially then to 2500 lbs for rest of recovery. Assume SP did input on EP's command rather than EP directly moving throttle. Slow climb out at about 500 ft/min. Came off stickshaker often as nose pushed down with trim.
No Aero/No Upset	FTE late with Event Marker. Nice recovery.	Evaluation pilot accelerated 25 knots, hesitated and did not increase pitch attitude for 8 seconds after event, then raised nose and climbed. AOA decreased slightly and came off stickshaker momentarily using trim commands.
No Aero/No Upset	EP asked for "firewall power." Good recovery. No event marker.	Evaluation pilot initiated aggressive pull to raise the nose quickly resulting in the fastest time to reach 500 ft/min (sharp pull caused a VSS Down mode for AOA 3 seconds after event start -- before airspeed decrease was done). Good recovery.
No Aero/No Upset		
Aero/No Upset	stick_shaker_alpha_setting = 6 deg originally, set to 8 deg until on final approach when it was reset back to 6 deg for upset.	Event marker used for start time not airspeed roll off. Airspeed increased 20 to 30 knots. Evaluation pilot made an abrupt large nose down input, then appeared to modulate pitch attitude to stay at the edge of stickshaker. Slow climb rate.
Aero/No Upset	EP recognized windshear. SP took control after event complete.	Event marker used for start time not airspeed roll off. Pitch attitude came up and stayed high through recovery.
Aero/No Upset	Started overlay to decrease airspeed then pushed event marker as SP retracted flaps. Roll oscillations due to over control on climb out.	Positive climb rate attained early but pilot pushed nose down and descended further and increased airspeed. Pilot was not consistently on the stick shaker.
Aero/No Upset	No windshear call from EP or SP.	Evaluation pilot pushed power up and was on the stickshaker before the event start.
Aero/No Upset	SP took control after recovery was complete.	Evaluation pilot allowed airspeed to decrease 25 knots further but continued to climb rapidly (3000 ft/min)
Aero/No Upset	EP set max power then called for gear and flaps. Good recovery.	Evaluation pilot did not attain 15 deg pitch attitude but stayed on stickshaker entire event and accepted low airspeed
Aero/No Upset	No event marker. Set max thrust, flew on shaker, and recovered.	Evaluation pilot failed to climb significantly, leveled off after losing 237 feet following the event. Evaluation pilot also increased airspeed while staying on the stickshaker.
Aero/No Upset	No event marker. EP checking radar for T-storms. EP pushed power up and called for flaps 9 degrees. Called for gear up when positive rate was indicated. Flew on shaker.	Evaluation pilot momentarily increased airspeed immediately following event but pitch attitude increased and speed bled back off.
No Aero/Upset	None	Thrust pushed up to 2500 to 3000 lb for entire maneuver. Pitch attitude increased over length of maneuver with AOA remaining relatively constant.
No Aero/Upset	None	Aggressive pull to increase pitch attitude made for a good recovery.
No Aero/Upset	No event marker. EP called for "flaps 7, positive rate gear up" and "escape, escape." EP applied full power immediately. Good recovery.	Aggressive pull to increase pitch attitude made for a good recovery. Nose down push only after climbing at over 3000 ft/min.
No Aero/Upset	No event marker. EP pushed power up, flew on shaker, and recovered.	Aggressive pull to increase pitch attitude made for a good recovery.
No Aero/Upset	EP called "set max power" and gear and flaps up.	Evaluation pilot came off stickshaker often. Not aggressive climb rate: aircraft was 400 ft AGL at event start and aircraft only climbed to 500 ft AGL by end of maneuver (30 sec).
No Aero/Upset	EP powered up immediately and flew on shaker for a good recovery. SP asked about low airspeed. EP responded with request for radar altitude.	Good recovery with pitch attitude and climb rate increasing rapidly after event start.
No Aero/Upset	EP asked for max thrust immediately. Flew on shaker and requested radar alt trends. EP said "no configuration change." Good recovery.	Good recovery with pitch attitude and climb rate increasing rapidly after event start.

Group	FTE Comments	Data Analyst Comments
No Aero/Upset		
Aero/Upset	None	Evaluation pilot was climbing during the entire event due to go-around initiation before event injected.
Aero/Upset	Good recovery. EP commented that he (she) "wasn't sure where shake is".	Small increase in airspeed allowed immediately following event, but nose kept up throughout maneuver
Aero/Upset	EP reported problems with aileron trim during approach (not part of scenario). Event marker as throttles were pushed up Good recovery.	Thrust was pushed up to 2200 lbs for entire recovery, whereas all other cases had a large initial thrust increase (about 4500 lbs) then pulled back. SP probably made thrust input on EP's command rather than EP directly moving throttles.
Aero/Upset	No event marker. EP powered up, flew on shaker, and recovered.	Pilot pushed nose down momentarily twice but kept on stickshaker.
Aero/Upset	No event marker. Set max thrust, flew on shaker, and recovered.	Thrust was kept at MAX for much longer than other maneuvers (12 seconds), not pulled back after initial increase.
Aero/Upset	No event marker. EP called for "set thrust, flaps 8" then "max power". EP brought gear up after quite a while (160 KIAS, 400 ft AGL and climbing). Good recovery.	Evaluation pilot started increasing thrust before event started. Altitude leveled off at the same time event was initiated. AOA dropped below stickshaker threshold during recovery. One of only events where AOA was not above stickshaker threshold at event start.
Aero/Upset	No event marker. EP added max power, called for "1/2 flaps." Good recovery.	Shorter time in overall maneuver than other cases accounts for slight decrease in % time in stickshaker.
Aero/Upset		
In-flight	EP called A/S decaying, added power, "positive rate,, gear up". Good recovery.	Thrust was pushed up to 2200 lbs for entire recovery, whereas all other cases had a large initial thrust increase (about 4500 lbs) then pulled back. SP probably made thrust input on EP's command rather than EP directly moving throttles.
In-flight	No event marker. EP added power. VSS tripped on AOA as EP firmly pulled the nose up.	Evaluation pilot increased airspeed by 25 knots but climb rate was still 1500 to 2000 ft/min. Evaluation pilot kept AOA low and came off shaker momentarily.
In-flight	No event marker. EP added power and flew on shaker. EP did not say "windshear." During initial part of approach, EP asked about windshear and gave an entire windshear briefing to SP.	Evaluation pilot accepted continued descent rate, kept nose low and increased speed until 18 sec after event start.
In-flight	EP set max power and flew on shaker to recover.	Evaluation pilot pushed nose down momentarily twice but kept on stickshaker.
In-flight	(FTE injected only moderate turbulence due to real turbulence in working area). No event marker. EP recognized stall but did not call "windshear." EP added go-around power and called missed approach. Good recovery.	Accelerated 20 knots after thrust input. Aircraft was descending slowly before event, and ascended slowly after event.
In-flight	EP immediately powered up, called to set go-around thrust and flew on shaker to recover. No windshear call. EP said he (she) didn't call "windshear" because the airplane the EP usually flies has automatic windshear advisory system.	Accelerated 20 knots immediately after event start. Came off stickshaker consistently as thrust came down.
In-flight	EP commented "Definitely squirrelly" while on approach and questioned, "yaw damp on?" EP called for max power, gear up, and flaps up. Flew on shaker. Good recovery.	Very long time slice - affects % time on shaker. Pitch attitude never went above 7 degrees and the evaluation pilot often came off stickshaker. Accelerated 15 knots after event. VERY slow climb - bobbled around zero climb rate.
In-flight		No data due to a broken wheel column.

5.3.5.2 Recovery Differences

Analyses were also performed to compare performance of evaluation pilots who recovered and the evaluation pilots who did not. Since 35 evaluation pilots did recover and only one evaluation pilot did not, anovas were not possible. In looking at the data the following results are striking – none of the evaluation pilots disengaged the autopilot

although this is stressed in airplane upset training in both the simulator and in-flight. Further about half (16) of the recovering evaluation pilots changed flap and gear settings while the other half (18) did not. It is clear from these data that the margin of tolerance around the selected performance parameters is quite large. Since the only evaluation pilot who did not recover from the Charlotte evaluation scenario was impeded by a safety trip, comparisons could not be made between evaluation pilots who recovered and the evaluation pilots who did not. Nor were there any clear indications of quality of recovery since all evaluation pilots who recovered did so effectively (i.e., within safety trip limits).

5.3.6 Pittsburgh

This accident occurred during initial approach during which a rudder hardover occurred. The correct recovery performance and the variables used to quantify that performance (see Table 57) were:

1. Announce problem.
    a. Time to announce problem.
2. Attitude crosscheck.
3. Disconnect (Autopilot, etc., etc.).
    a. Time to master disconnect
4. Attempt to use opposite rudder and aileron.
    a. Time to first correct rudder input
    b. Time to first correct aileron input
5. Unload pitch axis – push, don't pull.
    a. Time to first correct elevator input
    b. Phi at first correct elevator input
6. "Unload" pitch if more roll rate is required or if bank will exceed 70-90 degrees.
    a. FES input at phi = 70 degrees
7. Use split thrust to roll to wings level.
    a. Time to throttle split
8. Total thrust should be adjusted in consideration of both crossover speed and corner speed.
    a. Thrust delta
    b. Airspeed delta
9. Return to starting altitude/heading.
    a. Heading change
10. Inform ATC.
    a. Time to inform ATC of altitude and/or heading change
11. Troubleshoot rudder hardover.
    a. Time to troubleshoot rudder hardover

Only 8 (i.e., 22%) evaluation pilots recovered (1 out of 8 Aero/No Upset, 1 out of 6 No Aero/Upset, and 6 out of 7 In-flight). Three methods were used in the recoveries – airspeed alone, split thrust alone, and airspeed combined with split thrust. The first method was used by an evaluation pilot in the Aero/No Upset group, the second by one evaluation pilot in the No Aero/Upset group and four evaluation pilots in the In-flight group, and the combined method by two evaluation pilots in the In-flight group. A key error was failure to reduce the angle of attack after the initial full aileron control input did

not render the desired effect (see the number of blanks in Table 57 time to first correct elevator input column). Given that almost all of the In-flight group recovered while almost none of the other evaluation pilots in the other groups recovered, there may be a benefit of in-flight training, where alternate control application and the effect of yaw on bank angle change was briefed and demonstrated.

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.6). A summary of the recovery data is presented in Table 57. Means and standard deviations by group are presented in Table 58. The recovery data for the surprise scenario are presented in Table 59 and the associated means and standard deviations in Table 60. There were no significant differences. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and the evaluation pilots who did not. Means and standard deviations by recovery outcome are presented in Table 61. Values that are significantly different are shaded.

Table 57. Performance Data for Pittsburgh

Group	Time to Announce Problem (sec)	Time to Master Dis-connect (sec)	Time to First Correct Rudder Input (sec)	Time to First Correct Aileron Input (sec)	Time to First Correct Elevator Input (sec)	Phi at First Correct Elevator Input (deg)	FES Input at Phi = 70 degrees (lbs)	Time to Throttle Split (sec)	Thrust Delta (lb)	Airspeed Delta (KIAS)	Heading Change (deg)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Rudder Hardover (sec)	Recovered [148]	Method	Safety Trip
No Aero/No Upset	3		0.25	0.15	4.3	-41.92			-348	78.2	-114.4	1989			No		None
No Aero/No Upset			0.65	0.75	4.4	-77.65	26.28		-361	3.9	23.5	117			No		None
No Aero/No Upset	6.45		0.7	0.3			29.8		178	10.7	-2.5	300			No		None
No Aero/No Upset	1.25		0.45	0.9			40.21		13	10.6	-111.2	289			No		AOA, das, des
No Aero/No Upset	2.6		0.5	0.5			11.54		2	15.5	-102.2	376			No		None
No Aero/No Upset			0.45	1.25			-1.72	3.85	-223	2.3	24.8	103			No		None
No Aero/No Upset	4.75		0.5	0.6	0.8	1.02			-365	46.4	-96.1	1328			No		None
No Aero/No Upset			0.35	0.6	3.3	-33.84			1569	2.1	-46.2	0			No		AOA, Nz, das
Aero/No Upset	2.35		1.15	0.55	2.8	-24.81	49.94		23	53.6	-95.7	1240			No		None
Aero/No Upset	1.4	2.25	0.45	1.15			49.34	7.1	2271	28.3	-119	529			No		None
Aero/No Upset	6		0.15	0.55	1.1	-4.29	-0.62		-42	26.1	-67.6	529			No		AOA, Nz, das
Aero/No Upset			0.35	0.9	2.95	-32.59	3.33		1345	13.2	-90.9	225			No		None
Aero/No	7		0.05	0.2	1.8	-10.3			-116	41.4	-60.1	746			No		AOA.

[148] Return to straight and level flight.

Group	Time to Announce Problem (sec)	Time to Master Dis-connect (sec)	Time to First Correct Rudder Input (sec)	Time to First Correct Aileron Input (sec)	Time to First Correct Elevator Input (sec)	Phi at First Correct Elevator Input (deg)	FES Input at Phi = 70 degrees (lbs)	Time to Throttle Split (sec)	Thrust Delta (lb)	Airspeed Delta (KIAS)	Heading Change (deg)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Rudder Hardover (sec)	Recovered [148]	Method	Safety Trip
Upset																	das, des
Aero/No Upset	0.3		0.45	0.65	0.8	0.66			-348	87.1	-61.9	1572			Yes	A/S	ST-1, das
Aero/No Upset		19.5	1.4	1.55	1.8	-14.09			-577	84.9	-78.2	2128			No		None
Aero/No Upset	7.05		1	1	5.05	-69.11	-24.66		50	45.8	-67.7	1098			No		None
No Aero/Upset	2.05		0.1	1			19.87	4.65	11	46.6	-114.7	1035			No		None
No Aero/Upset	6.4		0.25	0.5			36.88		-9	5.7	-82.2	140			No		None
No Aero/Upset	1.15		0.45	1.05			11.07	1.8	589	3	-46.4	9			No		None
No Aero/Upset	1.4	13.35	0.85	0.9	13.7	-32.76		9.75	1057	39.1	-66.5	753			Yes	Split Thrust	None
No Aero/Upset			0.25	1.3			39.46		-228	0.9	-229.4	54			No		None
No Aero/Upset	0.8		2.65	1.85	4.5	-73.53	22.86		-24	3.5	-1.1	60			No		AOA, drp, das
No Aero/Upset [149]																	
No Aero/Upset [150]																	
Aero/Upset	3.9		0.3	1.1			0.31		-486	2.8	-15.8	23			No		None
Aero/Upset	8		0.75	0.75	22.6	-64.3			-1	52.2	-96.1	1544			No		None
Aero/Upset	6.4		0.1	0.5					-205	60.1	-83.2	1334			No		None
Aero/Upset	3.6			0.7			34.85		-6	6.1	-129.1	131			No		None
Aero/Upset	3.45		0.8	0.25	1.35	-10.27			673	13.1	-54.8	263			No		AOA, das

[149] Data missing due to computer failure during flight.
[150] Data missing due to severe thunderstorms that required use of ground simulation mode only.

Group	Time to Announce Problem (sec)	Time to Master Dis-connect (sec)	Time to First Correct Rudder Input (sec)	Time to First Correct Aileron Input (sec)	Time to First Correct Elevator Input (sec)	Phi at First Correct Elevator Input (deg)	FES Input at Phi = 70 degrees (lbs)	Time to Throttle Split (sec)	Thrust Delta (lb)	Airspeed Delta (KIAS)	Heading Change (deg)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Rudder Hardover (sec)	Recovered [148]	Method	Safety Trip
Aero/Upset	1.7		1.1	0.7	3.1	-36.2	3.67		-126	42.8	-96.7	1044			No		None
Aero/Upset	0.4		0.25	0.7	1.45	-5.2			432	11.5	-67.9	183			No		AOA, das, des
Aero/Upset [151]																	
In-flight	10		0.45	0.9	20.25	-10.4	22.31	6.25	559	81.8	-82.7	1844			Yes[152]	A/S & Split Thrust	None
In-flight	4.75		0.3	0.35	0.6	0.7		3.1	528	44.2	-31.6	499	19.9		Yes	Split Thrust	None
In-flight	0.8		0.25	0.5					-15	2.8	-36.4	58			No		AOA, drp, das
In-flight	1.2		0.5	0.5	6.05	-54.3		5.9	867	13.2	-51.1	479			Yes	Split Thrust	None
In-flight	1.25		0.75	0.75				25.1	1353	53.5	-57.5	1040			Yes	A/S & Split Thrust	None
In-flight	0.7		0.55	1.5				6.15	561	49.5	-81.6	1010			Yes	Split Thrust	None
In-flight	0.75		0.35	0.25				3.4	1196	39.5	-30	317			Yes	Split Thrust	None
In-flight[153]																	

[151] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[152] The increase in airspeed provided aileron and rudder effectiveness and thus enabled the pilot to recover in spite of not releasing back pressure.
[153] Data missing due to wheel column breaking during flight.

Table 58. Group Mean and Standard Deviation for Performance Data for Pittsburgh

Group	Time to Announce Problem (sec)	Time to Master Dis-connect (sec)	Time to First Correct Rudder Input (sec)	Time to First Correct Aileron Input (sec)	Time to First Correct Elevator Input (sec)	Phi at First Correct Elevator Input (deg)	FES Input at Phi = 70 degrees (lbs)	Time to Throttle Split (sec)	Thrust Delta (lb)	Airspeed Delta (KIAS)	Heading Change (deg)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Rudder Hardover (sec)	Recover	Method	Safety Trip
No Aero/No Upset																	
Mean	3.610	0 out of 8	0.481	0.631	3.200	-38.098	21.222	3.850	58.125	21.213	-53.038	562.750	0 out of 8	0 out of 8	0 out of 8		2 out of 8
Standard Deviation	2.020		0.146	0.344	1.675	32.287	16.430		643.760	27.152	60.871	709.668					
N	5		8	8	4	4	5	1	8	8	8	8					
Aero/No Upset																	
Mean	4.017	2 out of 8	0.625	0.819	2.329	-22.076	15.466	7.100	325.750	47.550	-80.138	1008.375	0 out of 8	0 out of 8	1 out of 8	Airspeed	3 out of 8
Standard Deviation	3.016		0.494	0.421	1.439	23.685	32.985		970.260	26.852	20.417	629.630					
N	6		8	8	7	7	5	1	8	8	8	8					
No Aero/Upset																	
Mean	2.360	1 out of 6	0.758	1.100	9.100	-53.145	26.028	5.400	232.667	16.467	-90.050	341.833	0 out of 6	0 out of 6	1 out of 6	Split thrust	1 out of 6
Standard Deviation	2.304		0.963	0.451	6.505	28.829	11.936	4.028	488.290	20.630	78.051	438.938					
N	5		6	6	2	2	5	3	6	6	6	6					
Aero/Upset																	2 out of 7
Mean	3.921	0 out of 7	0.550	0.671	7.125	-28.993	12.943		40.143	26.943	-77.657	646.000	0 out of 7	0 out of 7	0 out of 7		
Standard Deviation	2.596		0.390	0.258	10.348	27.173	19.046		392.090	23.931	36.111	639.344					
N	7		6	7	4	4	3	0	7	7	7	7					
In-flight																	
Mean	2.779	0 out of 7	0.450	0.679	8.967	-21.333	22.310	8.317	721.286	40.643	-52.986	749.571	19.9	0 out of 7	6 out of 7	2 airspeed and split thrust 4 split thrust	1 out of 7
Standard	3.493		0.171	0.425	10.144	29.084		8.341	461.370	26.258	22.310	598.795					

Group	Time to Announce Problem (sec)	Time to Master Dis-connect (sec)	Time to First Correct Rudder Input (sec)	Time to First Correct Aileron Input (sec)	Time to First Correct Elevator Input (sec)	Phi at First Correct Elevator Input (deg)	FES Input at Phi = 70 degrees (lbs)	Time to Throttle Split (sec)	Thrust Delta (lb)	Airspeed Delta (KIAS)	Heading Change (deg)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Rudder Hardover (sec)	Recover	Method	Safety Trip
Deviation																	
N	7		7	7	3	3	1	6	7	7	7	7					

Table 59. Performance Data for Pittsburgh Surprise

Group	Time to Announce Problem (sec)	Time to Master Dis-connect (sec)	Time to First Correct Rudder Input (sec)	Time to First Correct Aileron Input (sec)	Time to First Correct Elevator Input (sec)	Phi at First Correct Elevator Input (deg)	FES Input at Phi = 70 degrees (lbs)	Time to Throttle Split (sec)	Thrust Delta (lb)	Airspeed Delta (KIAS)	Heading Change (deg)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Trouble-shoot Rudder Hardover (sec)	Recovered [154]	Method	Safety Trip
No Aero/No Upset			1.35	1			23.31		-23	2.7	-122.4	100			No		Yes
No Aero/No Upset	2.2		0.6	1.2			29.1		0	7.4	-120.1	385			No		Yes
No Aero/No Upset			0.45	1.15			10.41		0	1.3	-44.1	104			No		Yes
No Aero/No Upset	2.45	1.95	0	0.9			21.23		-230	35.3	-56.2	848			No		Yes
Aero/No Upset	4.95	7.45	0.6	0.6	0.55	4.27	4.75		0	33.8	-70.7	1301			No	A/S	Yes
Aero/No Upset			0.3	0.6			2.11		12	15.4	-72.1	298			No		Yes
Aero/No Upset	2.25		0.85	0.9				9.75	937	84.8	-66.8	2113			Yes[155]	A/S & Split Thrust	Yes
No Aero/Upset	0.4		0.95	0.85			33.42		1	0.3	-8.8	34			No		Yes

[154] Stabilized flight within the normal flight envelop for transport category aircraft
[155] The increase in airspeed provided aileron and rudder effectiveness and thus enabled the pilot to recover in spite of not releasing back pressure.

No Aero/Upset	4.55		0.95	1.35			29.21		-454	-1.3	-84.6	2			No		Yes
No Aero/Upset	3.25		0.75	0.65			41.72		0	14.2	224	755			No		Yes
No Aero/Upset	1.55		1.15	1					0	-12.2	-49.4	639			Yes	A/S	Yes
Aero/Upset	10.45		1	1.1					89	78.5	-112	2678[156]			Yes[157]	A/S	Yes
In-flight			0.2	0.6				8.2	331	33.1	-50.5	697			Yes	Split Thrust	Yes
In-flight	1.85		0.85	0.75	1.6	-27.18			0	-0.1	-20.1	85			No		Yes

[156] There was 4500 feet to recover in the Pittsburgh accident. Therefore altitude losses below that were acceptable.
[157] The increase in airspeed provided aileron and rudder effectiveness and thus enabled the pilot to recover in spite of not releasing back pressure.

Table 60. Group Mean and Standard Deviation for Recovery Data for Pittsburgh[158]

Group	Time to Announce Problem (sec)	Time to Master Dis-connect (sec)	Time to First Correct Rudder Input (sec)	Time to First Correct Aileron Input (sec)	Time to First Correct Elevator Input (sec)	Phi at First Correct Elevator Input (deg)	FES Input at Phi = 70 degrees (lbs)	Time to Throttle Split (sec)	Thrust Delta (lb)	Airspeed Delta (KIAS)	Heading Change (deg)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Trouble-shoot Rudder Hardover (sec)	Method	Safety Trip
Recovery																
Mean	2.544	13.350	0.525	0.725	8.280	-19.220	22.310	8.521	721.625	[redacted]	-57.863	939.250	19.900	0 out o 8	1 airspeed 5 split thrust 2 combined	1 yes 7 no
Standard Deviation	3.315		0.189	0.394	8.552	23.894		7.634	533.333	23.932	19.940	542.696				
N	8	1	8	8	5	5	1	7	8	8	8	8	1			
No Recovery																
Mean	3.659	10.875	0.580	0.780	4.087	-33.139	19.578	4.350	143.714	[redacted]	-73.475	602.679		0 out of 28		8 yes 20 no
Standard Deviation	2.439	12.198	0.539	0.404	5.299	27.020	20.530	2.191	638.312	24.980	52.281	632.504				
N	22	2	27	28	15	15	18	4	28	28	28	28				

[158] Shading indicates significant difference.

Two sets of analyses were performed – those to evaluate the effects of different types of training and those to identify differences in performance between the evaluation pilots who recovered and the evaluation pilots who did not. Each of these is discussed in a separate section below.

5.3.6.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.6.1.1 Announce problem

There was no significant difference between groups on time to announce problem ($F(4, 25) = 0.396$, $p = 0.809$).

5.3.6.1.2 Attitude crosscheck

No quantitative data were available to measure this step in the recovery procedure.

5.3.6.1.3 Disconnect autopilot

Only three evaluation pilots disconnected the autopilot (2 in Aero/No Upset and 1 in No Aero/Upset).

5.3.6.1.4 Attempt to use opposite rudder and aileron

There were no significant differences among training groups in time to input rudder ($F(4, 30) = 0.407$, $p = 0.802$) or aileron ($F(4, 31) = 1.617$, $p = 0.195$).

5.3.6.1.5 Unload pitch axis – push, don't pull

There was no significant difference among training groups in time to the correct elevator input ($F(4, 14) = 1.026$, $p = 0.426$). Nor was there any difference between groups for the bank angle that evaluation pilots flew during the first elevator input ($F(4, 15) = 0.688$, $p = 0.624$).

5.3.6.1.6 "Unload" pitch if more roll rate is required or if bank will exceed 70-90 degrees

There was no significant difference in training groups in the force they applied to the elevator ($F(4, 14) = 0.232$, $p = 0.916$).

5.3.6.1.7 Use split thrust to roll to wings level

Very few evaluation pilots used split throttle except for the In-flight group where all but one used this technique to attempt recovery (1 out of 8 in No Aero/No Upset and Aero/No Upset groups, 3 out of 6 in No Aero/Upset group, and none in Aero/Upset group).

5.3.6.1.8 Total thrust should be adjusted in consideration of both crossover speed and corner speed

There were no significant differences between groups in the change in either thrust ($F(4, 31) = 1.316$, $p = 0.286$) or airspeed ($F(4, 31) = 1.942$, $p = 0.128$).

5.3.6.1.9 *Return to starting altitude/heading*

There was no significant difference among training groups in either heading ($F(4, 31) = 0.881$, $p = 0.487$) or altitude ($F(4, 31) = 1.110$, $p = 0.369$).

5.3.6.1.10 *Inform ATC*

Only one evaluation pilot (In-flight group) informed ATC of altitude and heading change.

5.3.6.1.11 *Troubleshoot rudder hardover*

None of the evaluation pilots began troubleshooting the rudder hardover.

5.3.6.1.12 *Safety trips and comments*

Very few of the evaluation pilots experienced safety trips since very few of the evaluation pilots put in enough of a rudder input to cause a safety trip. The safety trip did affect the recovery of the one evaluation pilot in the In-flight group who did not recover due to excessive AOA.

The Pittsburgh evaluation scenario was also used as one of the surprise scenarios on the return to base. The results were mixed. Although some of the groups responded on average faster, they did not respond quickly with correct responses. There was one additional recovery – this one from an evaluation pilot in the Aero/Upset group. This same evaluation pilot lost over 2600 feet altitude, however.

There were extensive comments during the flight regarding these recoveries. These comments are presented in Table 61. It was clear that many evaluation pilots put in very large rudder inputs (up to 100 pounds force). Some even made very large aileron inputs. But the variability in the amount of force applied among evaluation pilots was great. Recovery techniques varied as well. When split throttle was used, there was one occurrence of using the wrong engine for thrust.

Table 61. Comments on Airplane Upset Recovery Performance Data for Pittsburgh

Group	Recover	Method	Safety Trip	Comments
No Aero/No Upset	No	N/A	None	EP pushed twice and actually had bank angle decreasing before pulling again to continue the roll to the left. SP took control while still rolling. Good example of pushing to increase roll effectiveness.
No Aero/No Upset	No	N/A	None	SP took rolling through phi ~-100 deg.
No Aero/No Upset	No	N/A	None	EP made large rudder AND aileron inputs (> 100 lb each). SP took control rolling through ~ -90 deg.
No Aero/No Upset	No	N/A	AOA, das, des	None
No Aero/No Upset	No	N/A	None	SP took control with nose very low (theta ~-35 deg). EP not feeling well (vomited during car ride to airport to catch flight home after debrief).
No Aero/No Upset	No	N/A	None	EP stomped on right pedal but didn't use much aileron. Pitch inputs were minimal both + and -. EP commented that didn't want to use much aileron because of spoiler deployment in DC-9 (pilots are taught not to use full aileron near stall)
No Aero/No Upset	No	N/A	None	EP holding ~ 18 lb. left rudder pedal and pushing forward with ~5 lb. on wheel at upset. Pushed twice at beginning of upset, then pulled for remainder of scenario. SP took control in dive.

Group	Recover	Method	Safety Trip	Comments
No Aero/No Upset	No	N/A	AOA, Nz, das	EP split thrust with increased right engine thrust (wrong engine).
Aero/No Upset	No	N/A	None	EP unloaded twice and had bank angle decreasing before pulling and continuing to roll left. SP took control in dive.
Aero/No Upset	No	N/A	None	EP carrying ~ -5 lb. left rudder pedal and ~ -5 lb. left aileron at upset start. SP took control with phi~-85 deg.
Aero/No Upset	No	N/A	AOA, Nz, das	EP pushed on wheel initially before pulling twice then pushing once more (fes ~ -57 lb) as VSS tripped. Every time EP pushed the roll rate decreased to zero but then EP pulled and roll continued. Good example of pushing to gain roll control.
Aero/No Upset	No	N/A	None	EP did push with ~35 lb. force in middle of scenario but then let up and pulled slightly. SP took control in dive with phi ~90 deg and increasing.
Aero/No Upset	No	N/A	AOA, das, des	EP made +/-20 lb. inputs to rudder pedals prior to upset. EP pushed on wheel then pulled for ~ remainder of scenario. EP powered up to 2644 lb thrust prior to pulling power off just prior to VSS trip. Good example of pushing to get more roll control.
Aero/No Upset	Yes	A/S	ST-1, das	Initial EP inputs were left aileron and left pedal before reversing. EP pushed power up to 2923 lb. then pulled to idle just before VSS tripped. Bank angle under control but still diving (hdot decreasing, however) when VSS tripped.
Aero/No Upset	No	N/A	None	EP was pushing on yoke prior to start of upset. SP took control in dive.
Aero/No Upset	No	N/A	None	SP took control in dive.
No Aero/Upset	No	N/A	None	EP split throttles but then pulled left throttle back just before SP took control. Was actually starting to roll back towards zero phi until pulled left engine back and left roll continued.
No Aero/Upset	No	N/A	None	EP gave aircraft control back to SP.
No Aero/Upset	No	N/A	None	EP didn't apply much aileron. Split throttles but not enough soon enough and didn't leave split in. Took throttle split out just before SP took control in left bank with bank angle increasing.
No Aero/Upset	Yes	Split Thrust	None	EP held master disconnect down.
No Aero/Upset	No	N/A	None	SP took control in dive. EP did not apply full opposite aileron.
No Aero/Upset	No	N/A	AOA, drp, das	EP pushed right pedal followed by left pedal.
No Aero/Upset				
No Aero/Upset				
Aero/Upset	No	N/A	None	EP applied right rudder pedal but not much right aileron. EP was pushing (fes ~ -10 lb) when upset started. SP took control with phi ~ -100 deg and increasing.
Aero/Upset	No	N/A	None	SP took control with A/C still rolling left.
Aero/Upset	No	N/A	None	EP holding ~ 10 lb. right rudder pedal at upset. SP took control in dive.
Aero/Upset	No	N/A	None	20-40 lb. right rudder pedal inputs in the 10 sec before upset. Frp > 10 lb. at upset. EP pulled aft ~ 70 lb. SP took control in dive with bank angle increasing.
Aero/Upset	No	N/A	AOA, das	EP pushed on wheel for first half of event before pulling.
Aero/Upset	No	N/A	None	EP holding ~ 12 lb left rudder pedal as event started. SP took control in dive.
Aero/Upset	No	N/A	AOA, das, des	EP momentarily pushed before continuing to pull aft on wheel.
Aero/Upset				
In-flight	Yes	A/S & Split Thrust	None	EP initially pushed only the right engine power up. Good "Textbook" example
In-flight	Yes	Split Thrust	None	EP pushed briefly at beginning of event then pulled for next 10 seconds.
In-flight	No	N/A	AOA, drp, das	Phi ~ -62 deg and steepening when VSS tripped.
In-flight	Yes	Split Thrust	None	Max phi ~ -56 deg. EP pushed only once for brief time, pulling all other times. EP requested that SP split throttles for him (her)

Group	Recover	Method	Safety Trip	Comments
In-flight	Yes	A/S & Split Thrust	None	Max phi ~ -35 deg. EP split thrust very late. Most of recovery due to A/S.
In-flight	Yes	Split Thrust	None	Max phi ~ -66 deg.
In-flight	Yes	Split Thrust	None	Max phi ~ -31 deg.
In-flight				

5.3.6.2 Recovery Differences

The performance of evaluation pilots who recovered was compared to the performance of evaluation pilots who did not recover. There was no significant difference in time to announce the problem ($F(1, 28) = 1.012$, $p = 0.323$), make the first correct rudder input ($F(1, 33) = 0.078$, $p = 0.782$), correct aileron input ($F(1, 34) = 0.118$, $p = 0.734$), correct elevator input ($F(1, 18) = 1.731$, $p = 0.205$), or throttle split ($F(1, 9) = -1.095$, $p = 0.323$). Only three evaluation pilots used the master disconnect – one in the recovery group and the other two in the group that did not recover. There were no significant differences in phi at the first correct elevator input ($F(1, 18) = 1.046$, $p = 0.320$). Only one evaluation pilot in the recovery group made FES input when the bank angle was 70 degrees – all others had already recovered prior to this bank angle. Nor was there a significant difference in the change in thrust between evaluation pilots who recovered and those who did not ($F(1, 34) = 5.438$, $p = 0.026$). However, the evaluation pilots who recovered (50.988 KIAS) had a significantly greater change in airspeed than evaluation pilots who did not recover (25.504 KIAS) ($F(1, 34) = 6.587$, $p = 0.015$). But there was no significant difference between the two groups in heading change ($F(1, 34) = 0.673$, $p = 0.418$) or altitude lost ($F(1, 34) = 1.863$, $p = 0.181$). Only one evaluation pilot informed ATC of the altitude deviation. That evaluation pilot recovered the aircraft. None of the evaluation pilots in either group troubleshot the rudder hardover.

As stated previously evaluation pilots used three techniques to recover from the Pittsburgh evaluation scenario: airspeed alone (1 evaluation pilot), split thrust alone (5 evaluation pilots), and airspeed combined with split thrust (2 evaluation pilots). There was no significant difference in the frequency of occurrence in safety trips between the evaluation pilots who recovered (1 out of 7) and the evaluation pilots who did not (8 out of 28) ($\chi^2(1) = 0.857$, $p \leq 1.000$). The safety trips that occurred were all AOA and das. Three also included des, 2 drp, and 2 Nz.

5.3.7 Roselawn

This accident occurred during manual descent due to the gradual buildup of ice on the wings. The correct recovery performance and the variables used to quantify that performance (see Table 62) were:

1. Announce problem.
    a. Time to announce problem
2. Use full opposite aileron, rudder, and possibly split thrust to roll to wings level.
    a. Time to correct aileron input
    b. Time to correct rudder input
    c. Time to correct throttle input
3. Angle of attack should be reduced:
    a. Time to correct elevator input

    b. Time to correct (split) throttle input
4. Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed.
    a. Max airspeed
5. Flaps should be set back to 20°.
    a. Time to set flaps back to 20 degrees
6. Return to starting altitude/heading.
    a. Altitude lost
7. Inform ATC.
    a. Time to inform ATC of altitude/heading change
8. Troubleshoot deice system.
    a. Time to troubleshoot deice system

Roselawn was a difficult scenario from which to recover. Only 15 out of 35 (i.e., 43%) evaluation pilots for which there were complete data set were able to do so: 2 out of 6 in the No Aero/No Upset group, 4 out of 8 in the Aero/No Upset group, 1 out of 7 in the No Aero/Upset group, 2 out of 7 in the Aero/Upset group, and 6 out of 7 in the In-flight group. Note that the In-flight group had received previous training on recovering from a Roselawn-type scenario. Further, the only evaluation pilot in the In-flight group who did not recover from this scenario may have been impeded from doing so by a safety trip. A key error was not pushing to reduce the angle of attack. Extensive post flight debriefing indicated that stall recovery training as currently implemented in transport category training is not necessarily going to help in stalls due to icing. As the evaluation pilots stated, the training they received was stick shaker recovery (power out without losing altitude) not ice-induced stall recovery training.

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.7). A summary of the recovery data is presented in Table 62. Means and standard deviations by group are presented in Table 63. There were no significant differences between training groups. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and those who did not. Means and standard deviations by recovery outcome are presented in Table 64. Values that are significantly different are shaded.

Table 62. Performance Data for Roselawn

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to First Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude/Heading Change (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recovered[159]
No Aero/No Upset	2	0.00	1.16			0.45	203.91		670.92			No		No
No Aero/No Upset		0.00	0.00				262.64		2613.00			No		No
No Aero/No Upset	1	0.30	0.00			5.35	211.47		662.34			Yes - 7.0	No	No
No Aero/No Upset	4	2.25	2.80		3.55	5.15	220.31		445.92			No	No	Yes
No Aero/No Upset	7	0.15	0.65		18.00	7.10	224.35		478.65	9.80		No	No	No
No Aero/No Upset	6	0.00	0.40				253.36	6	2083.63			No	No	Yes
No Aero/No Upset[160]														
No Aero/No Upset[161]														
Aero/No Upset	0[162]	0.00	1.80		0.80	5.45	209.48		401.44	39.95		No		Yes
Aero/No Upset	1	0.05	0.00				231.64		1034.61			No		No
Aero/No Upset	1	1.14	1.75		2.00		190.00		445.39			Yes - 2.8	No	No
Aero/No Upset	5	0.25	0.95				193.00		235.50			No	No	Yes
Aero/No Upset	5	0.00	0.00		9.60	5.80	206.24	5	474.06			No	No	No
Aero/No Upset	0	0.05	1.60		3.40	1.05	226.11		48.18	1.55		No	No	Yes

159 Stabilized flight within the normal flight envelop for transport category aircraft.
160 Data missing due to wheel column breaking during flight.
161 Data missing due to computer failure during flight.
162 Response occurred at onset of airplane upset.

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to First Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude/Heading Change (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recovered[159]
Aero/No Upset	-1	0.00	0.00		3.80	9.70	213.10		558.54	9.50		No	No	Yes
Aero/No Upset		0.00	0.80				184.50		50.50			Yes	Yes	No
No Aero/Upset	-5	0.00	0.10			37.45	203.70		558.90	18.40		No		No
No Aero/Upset		1.25	1.25			0.00	183.75		184.62			No		No
No Aero/Upset	8	0.60	0.40				201.50		1186.74			No	No	No
No Aero/Upset	1	0.00	0.75	5.45		1.85	263.38		1737.00			No	No	Yes
No Aero/Upset	0	0.00	0.10		0.95	0.85	204.50		582.52			No	No	No
No Aero/Upset		0.00	0.25				206.50		137.50			Yes	Yes	No
No Aero/Upset	1	0.00	0.40				175.00		42.70			Yes	Yes	No
No Aero/Upset[163]														
Aero/Upset	1	0.00	0.85				201.80		1150.10	7.70		No		No
Aero/Upset	8	0.65	1.35		31.11		211.93		1269.99			No	No	Yes
Aero/Upset	5	0.05	0.95		0.30	0.85	217.48		323.83	7.50		No	No	Yes
Aero/Upset	43	0.10	0.05				205.10		467.50			No	No	No
Aero/Upset	4	0.50	0.00				188.50		47.50			Yes	Yes	No
Aero/Upset	3	0.10	0.00		0.00		210.50		550.50			Yes	No	No
Aero/Upset	3	0.00	0.40		1.70	0.55	196.18		61.37			Yes	No	No
Aero/Upset[164]														
In-flight	12	0.00	0.50				218.85		916.67			No	No	Yes
In-flight	-1	0.00	0.00		0.80	0.70	252.89		667.44	4.45		No	No	Yes

[163] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[164] Data missing due to severe thunderstorms that required use of ground simulation mode only.

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to First Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude/Heading Change (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recovered[159]
In-flight	1	0.00	0.90				190.60		110.00			Yes	Yes	No
In-flight	-2	0.00	0.55		0.90	8.60	194.58	-2	286.11			No	No	Yes
In-flight	0	0.10	0.70		3.15		208.46	9	462.87	25.40		No	No	Yes
In-flight	0	0.00	0.30	6.25	11.90	2.05	230.89		161.89			No	No	Yes
In-flight	5	0.00	0.40	4.45	2.15	11.05	238.45		422.98			No	No	Yes
In-flight[165]														

[165] Data missing due to wheel column breaking during flight.

Table 63. Group Mean and Standard Deviation for Performance Data for Roselawn

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to First Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude/Heading Change (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recover
No Aero/No Upset														
Mean	4.080	0.450	0.835	0 out of 6	10.775	4.512	229.340	1 out of 6	1159.077	1 out of 6	0 out of 6	1 out of 6	0 out of 6	2 out of 6
Standard Deviation	2.386	0.890	1.057		10.218	2.846	23.487		940.777					
N	5	6	6		2	4	6		6					
Aero/No Upset														
Mean	1.429	0.186	0.863	0 out of 8	3.920	5.500	206.759	1 out of 8	406.028	17.000	0 out of 8	2 out of 8	1 out of 8	4 out of 8
Standard Deviation	2.259	0.395	0.798		3.390	3.537	16.933		318.054	20.269				
N	77	8	8		5	4	8		8	3				
No Aero/Upset														
Mean	1.270	0.264	0.464	1 out of 7	0.950	10.038	205.476	0 out of 7	632.854	1 out of 7	0 out of 7	2 out of 7	2 out of 8	1 out of 7
Standard Deviation	4.659	0.489	0.412			18.291	28.209		622.964					
N	5	7	7		1	4	7		7					
Aero/Upset														
Mean	9.464	0.200	0.514	0 out of 7	8.278	0.700	204.499	0 out of 7	552.970	7.600	0 out of 7	3 out of 7	1 out of 7	2 out of 7
Standard Deviation	15.148	0.263	0.541		15.240	0.212	9.938		487.796	0.141				
N	7	7	7		4	2	7		7	2				
In-flight														
Mean	2.179	0.014	0.479	5.35	3.780	5.600	219.246	4	432.566	14.925	0 out of 7	1 out of 7	1 out of 7	6 out of 7
Standard Deviation	4.670	0.038	0.288	1.2728	4.641	5.010	23.028	7.990	285.569	14.814				
N	7	7	7		5	4	7		7	2				

Table 64. Group Mean and Standard Deviation for Recovery Data for Roselawn[166]

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to First Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude/Heading Change (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery
Recovery													
Mean	2.740	0.223	0.870	5.380	5.375	7.194	[illegible]	4.420	668.133	11.967	0 out of 15	[illegible]	[illegible]
Standard Deviation	3.853	0.586	0.753	0.900	7.080	12.549	20.925	5.770	591.435	5.670			
N	15	15	15	3	6	8	15	3	15	3		15	14
No Recovery													
Mean	4.822	0.210	0.453		5.624	4.645	[illegible]		575.471	14.725	0 out of 20	[illegible]	[illegible]
Standard Deviation	10.712	0.379	0.514		9.038	3.952	19.258		598.057	14.892			
N	16	20	20	0	11	10	20		20	6		20	14

[166] Shading indicates significant difference.

Two sets of analyses were performed – those to evaluate the effects of different types of training and those to identify differences in performance between the evaluation pilots who recovered and the evaluation pilots who did not. Each of these is discussed in a separate section below.

5.3.7.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.7.1.1 *Announce problem*

There was no significant difference between groups in time to announce the problem ($F(4, 26) = 1.242$, $p = 0.318$).

5.3.7.1.2 *Use full opposite aileron, rudder, and possibly split thrust to roll to wings level*

There were no significant differences between groups in time to make control inputs (aileron input ($F(4, 30) = 0.693$, $p = 0.602$), rudder ($F(4, 30) = 0.637$, $p = 0.640$), or throttle ($F(4, 13) = 0.373$, $p = 0.824$). Only three evaluation pilots used split throttle: 1 in the No Aero/Upset group and 2 in the In-flight group. Therefore, an anova was not calculated.

5.3.7.1.3 *Angle of attack should be reduced*

There were no significant differences among the training groups in time to make the first correct elevator input ($F(4, 12) = 0.432$, $p = 0.783$).

5.3.7.1.4 *Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed*

There were no significant differences between groups in maximum airspeed ($F(4, 30) = 1.733$, $p = 0.169$)

5.3.7.1.5 *Flaps should be set back to 20°*

Only four of the evaluation pilots returned the flaps back to 20 degrees (1 in No Aero/No Upset group, 1 in Aero/No Upset group, and 2 in In-flight group).

5.3.7.1.6 *Return to starting altitude/heading*

There were no significant differences among training groups in altitude lost ($F(4, 30) = 1.909$, $p = 0.135$).

5.3.7.1.7 *Inform ATC*

Less than one third of the evaluation pilots informed ATC of an altitude and/or heading change (1 out of 6 No Aero/No Upset group, 3 out of 8 Aero/No Upset group, 1 out of 7 No Aero/Upset group, and 2 out of 7 Aero/Upset and In-flight groups).

5.3.7.1.8 *Troubleshoot deice system*

None of the evaluation pilots began to troubleshoot the deicing system.

5.3.7.1.9 Safety trips and comments

Safety trips did occur and did affect five evaluation pilots' ability to recover but not to make initial recovery inputs (1 out of 8 in Aero/No Upset group, 2 out of 8 in No Aero/Upset group, and 1 out of 7 in Aero/Upset and In-flight groups). The criteria for safety trips are presented in Table 25.

There were extensive comments during the flight regarding these recoveries. These comments are presented in Table 65. Several evaluation pilots got into series of roll oscillations. Many disregarded ATC, e.g., ("we're gonna do 220 whether they approve it or not"). There was also a wide range of diagnoses on the cause of the upset from hardover to frozen controls.

Table 65. Comments on Airplane Upset Recovery Performance Data for Roselawn

Group	Safety Trip	Safety Trip Affect Recovery	Recover	Comments
No Aero/No Upset	No	N/A	No	EP asked for icing boots.
No Aero/No Upset	No	N/A	No	Got into upset just as ATC call to slow to 150 KIAS was given. SP took control of aircraft while in upset.
No Aero/No Upset	Yes - 7.0	No	No	Made FTE work to get into upset. Due to icing, EP didn't want to go above 175 KIAS so he/she didn't have to observe 180 KIAS flap extend speed. snatcher_alpha_setting set to 3.5 deg with flaps 20 deg. Nominal AOA with flaps 20 deg prior to turn call was ~ 2.5 deg.
No Aero/No Upset	No	No	Yes	FTE had to set snatcher_alpha_setting = 5.5 deg.
No Aero/No Upset	No	No	No	snatcher_alpha_setting reduced to 4 deg to force upset. Increased power but VSS tripped on drdot in middle of roll oscillations. EP was using rudder to help the roll rate.
No Aero/No Upset	No	No	Yes	EP got into upset as flaps were retracted. EP asked for flaps back down (Lear flaps not moved) and powered up to recover. 250 KIAS as SP took control after recovery complete.
No Aero/No Upset				
No Aero/No Upset				
Aero/No Upset	No	N/A	Yes	None
Aero/No Upset	No	N/A	No	EP asked for emergency trim. SP took control of aircraft while in upset.
Aero/No Upset	Yes - 2.8	No	No	Good maneuver this time. Large amplitude right roll before SP took control.
Aero/No Upset	No	No	Yes	snatcher_alpha_setting reduced to 5 deg to force upset. EP got upset twice and powered up to recover twice before SP ended scenario.
Aero/No Upset	No	No	No	EP requested flaps back down to 20 deg after got into upset. snatcher_alpha_setting = 5.8 deg.
Aero/No Upset	No	No	Yes	EP added full power after commenting that the "airplane is squirrelly." Not much of an upset before EP intervened. Good recovery.
Aero/No Upset	No	No	Yes	No power up but good recovery. EP stated that we'd need 4000 ft MSL (maneuver started at 5000 ft MSL) then stated that we'd need 210 KIAS (upset started at ~ 180 KIAS). Throttle cut at 63.5 seconds
Aero/No Upset	Yes	Yes	No	VSS tripped on AOA and ST-1 shortly after upset began. No turn call from ATC required. EP using aileron and rudder to roll.
No Aero/Upset	No	N/A	No	"ATC" had to give another turn call to get into upset.
No Aero/Upset	No	N/A	No	None
No Aero/Upset	No	No	No	SP took control in upset.
No	No	No	Yes	EP recovered at 260 KIAS after a good series of roll oscillations.

Group	Safety Trip	Safety Trip Affect Recovery	Recover	Comments
Aero/Upset				
No Aero/Upset	No	No	No	EP pulled power to idle, pushed nose down to get 210 KIAS. VSS trip on drdot and das.
No Aero/Upset	Yes	Yes	No	VSS trip on drdot (using rudder to help roll) after one roll upset to the right. Had to set snatcher_alpha_setting = 3.2 deg to get upset due to higher speed than requested.
No Aero/Upset	Yes	Yes	No	Big roll right initially, from which SP took control. EP pulled aft. Did not recover.
No Aero/Upset				
Aero/Upset	No	N/A	No	None
Aero/Upset	No	No	Yes	EP went to idle power during upset. SP was calling to watch altitude as aircraft was descending.
Aero/Upset	No	No	Yes	One upset then EP powered up. Asked SP to request 190 KIAS then 220 KIAS from ATC. Very firm about 220 KIAS ("we're gonna do 220 whether they approve it or not"). Good recovery.
Aero/Upset	No	No	No	Extremely long record for this upset. EP got into upset once at ~ 50 sec, then not again until ~90 sec. Recovered every time EP pushed forward then got back into upset as EP pulled aft. SP took control in upset, not recovered.
Aero/Upset	Yes	Yes	No	EP requested max thrust. SP took control in upset.
Aero/Upset	Yes	No	No	SP took control in upset while rolling right. No need for ATC call to turn.
Aero/Upset	Yes	No	No	EP applied max power. VSS trip on AOA after two roll oscillations.
Aero/Upset				
In-flight	No	No	Yes	FTE reset snatcher_alpha_setting to 5.2 deg in turn to get upset. No power change. V=201 KIAS with right wing down (cross control) when SP took control after recovery.
In-flight	No	No	Yes	EP permitted descent to 4000 ft MSL, V=250 KIAS to successfully recover. Asked SP to declare an emergency.
In-flight	Yes	Yes	No	Short event. VSS trip on das. EP called "hardover."
In-flight	No	No	Yes	EP called flaps up then flaps back down immediately after upset appeared to correlate with flap movement. EP applied max power and flew out of upset.
In-flight	No	No	Yes	EP asked for help with aileron and mentioned he had rudder control. EP requested flaps back down. Declared emergency. Recovered holding right wing down. EP initially called for flaps above the flap extend speed (Time for this initial flap request denoted in data).
In-flight	No	No	Yes	EP powered up immediately, said "frozen controls, good rudder." V=230 KIAS at recovery.
In-flight	No	No	Yes	EP wanted SP to "leave flaps where they are" when told to retract flaps
In-flight				

5.3.7.2 Recovery Differences

Comparisons were also made on performance between evaluation pilots who recovered and the evaluation pilots who did not. There were no significant differences in time to announce the problem ($F(1, 29) = 0.504$, $p = 0.483$). Nor were there significant differences in time to made first correct control inputs (aileron ($F(1, 33) = 0.007$, $p = 0.933$), rudder ($F(1, 33) = 3.797$, $p = 0.060$), elevator ($F(1, 15) = 0.003$, $p = 0.954$), or throttle ($F(1, 16) = 0.372$, $p = 0.551$)). Only three of the 20 evaluation pilots who recovered correctly split the throttles prior to making an elevator input. None of the evaluation pilots who did not recover did this, however. Further, only three evaluation pilots (all in the recovery group) set the flaps back to 20 degrees).

There was a significant difference between the two groups in max airspeed. The evaluation pilots who recovered had significantly higher airspeeds (223 KIAS) than the evaluation pilots who did not recover (204 KIAS) ($F(1, 33) = 8.050$, $p = 0.008$). There was no difference, however, in altitude loss ($F(1,33) = 0.208$, $p = 0.652$) or time to inform ATC of altitude or heading change ($F(1, 7) = 0.091$, $p = 0.772$). Further, none of the evaluation pilots in either grouped troubleshot the deicing system.

Recovery from stall due to icing is not correctly taught (see section 5). As in any stall recovery the amplitude of the input is critical and AOA reduction is not indicated only by change in airspeed. Initial large amplitude input typically result in quickly recovering from the stall without large altitude loss or airspeed increase. Smaller or later inputs typically result in larger altitude losses and higher recovery speeds.

There was a significant difference in the number of safety trips between the evaluation pilots who recovered (0) and those who did not (9) ($\chi^2(1) = 9.087$, $p \leq 0.010$). All safety trips occurred after the initial inputs were made. There was also a significant difference in occurrence of safety trips that affected whether the evaluation pilot could recover or not ($\chi^2(1) = 13.263$, $p \leq 0.001$). This analysis was based on the same 9 safety trips as the previous analysis. All occurred because the evaluation pilot failed to make the appropriate recovery response.

5.3.8 Detroit

This accident involved a rapid descent after an uncommanded roll excursion due to wing icing. The correct recovery performance and the variables used to quantify that performance (see Table 66) were:

1. Announce problem
    a. Time to announce problem
2. Angle of attack should be reduced:
    a. Time to correct aileron input
    b. Time to correct rudder input
    c. Time to correct throttle input
    d. Time to correct throttle split
3. Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed.
    a. Time to correct elevator input
    b. Max airspeed
4. Flaps may be set to 20°, speed permitting.
    a. Time to set flaps back to 20 degrees
5. Return to starting altitude/heading.
    a. Altitude lost
6. Inform ATC.
    a. Time to inform ATC of altitude deviation
7. Troubleshoot deice system.
    a. Time to troubleshoot deice system

Recovering from the Detroit scenario was difficult. A little less than half of the evaluation pilots (i.e., 44%) did recover (3 out of 8 No Aero/No Upset group, 4 out of 8 Aero/No Upset group, 2 out of 8 No Aero/Upset group, 5 out of 8 Aero/Upset group, and 2 out of 8 In-flight group). Like Roselawn, a key error for the Detroit scenario was not pushing to reduce the angle of attack. Again, post flight debriefing indicated that stall recovery training as currently implemented was not necessarily going to help in stalls due to icing since it is in fact approach to stall recovery that is trained. As the evaluation pilots stated, the training they received was stick shaker recovery not icing recovery training.

The complete safety pilot and flight test engineer scripts introducing this scenario are presented in Appendix D (section 11.8). A summary of the recovery data is presented in Table 66. Means and standard deviations by group are presented in Table 67. There were no significant differences due to training group. In addition to comparing performance across types of airplane-upset training, comparisons were made between evaluation pilots who recovered and the evaluation pilots who did not. Means and standard deviations by recovery outcome are presented in Table 68. Values that are significantly different are shaded.

Table 66. Performance Data for Detroit

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 Degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recovered[167]
No Aero/No Upset		0.95	0.95		1.35	2.95	191.55		326.67			Yes - 23.1	No	No
No Aero/No Upset		0.85	0.85				186.5		100.95			Yes - 10.15	No	No
No Aero/No Upset	5.2	1.15	1.15		1.6	2.65	190.29		202.08			No		Yes
No Aero/No Upset		1.05	1.45			3.45	194.8	70	435.21	86		Yes - 14.10	No	No
No Aero/No Upset	0.7	0.95	1.45		2.15	2.65	248.02		1458.92			Yes - 21.10	No	No
No Aero/No Upset	4.4	1.05	1.3		1.45	4.6	221.88		377.51			No		Yes
No Aero/No Upset	3.35	0.9	1.4		5.35	12	229.57	62	856.07			No		Yes
No Aero/No Upset		0.6	1.2	3.55	4.75	3.15	220		710.75			Yes - 16.50	No	No
Aero/No Upset	2.45	5.35	5.75				151.13		62.43			No		Yes
Aero/No Upset	1.45	0.75	0.75		0.55	1.6	191.9		58.1			No		Yes
Aero/No Upset		0.8	1.15			13.55	198.49		506.41			No		No
Aero/No Upset		1.2	1.1		1.6							Yes - 2.45	Yes	No
Aero/No Upset		0.85	1.1		7.15	2.25	212.2		208.33			Yes - 13.70	No	No
Aero/No Upset	2.5	0.85	1.1		1.7	1.65	208.2		321.94			No		Yes
Aero/No Upset		1.6	1.05		1.7	2	181.5		88.89			Yes - 5.95	No	No
Aero/No Upset		0.9	1.05		7.68		230.57		2212.53			No		Yes
No	5.55	0.95	1.1		14.21	2.75	254.16		729.29	94		No		Yes

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Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 Degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recovered[167]
Aero/Upset														
No Aero/Upset		0.85	0.95			3.15	190.99		373.59			No		No
No Aero/Upset	2.05	1.1	1.1		2.05	2.95	239.95		919.85			No		Yes
No Aero/Upset	4.8	1.05	1.4	2.3	1.8	5.3						Yes - 5.65	Yes	No
No Aero/Upset	13.95	0.95	1.05				224.94		1643.1			No		No
No Aero/Upset	-0.45	0.8	1.1		2.95		222.5		824.33			Yes - 13.50	No	No
No Aero/Upset[168]														
No Aero/Upset[169]														
Aero/Upset	14.6	0.95	1.2		1.6	42.25	216.59		1360.92			No		Yes
Aero/Upset	6.8	1	0.85			4	240.65		1314.21			No		Yes
Aero/Upset	2.2	1.5	0.35		2.05	5.9	216.87		472.24			No		Yes
Aero/Upset	3.3	0.9	0.4			6.05	225.2		1075.1			Yes - 16.70	No	No
Aero/Upset	4.2	1.25	1.85		2.95	2.85	213.5		1022.16			No		Yes
Aero/Upset	0.2	0.8	2.75		1.2	2.65	245.02		1257.8			No		Yes
Aero/Upset	2.65	1.3	1.15		1.75	2.85	173		0			Yes - 9.15	Yes	No
Aero/Upset[170]														
In-flight		0.85	1.05		1.3		219.34		1475.37			Yes - 22.90	No	No
In-flight	13.5	0.9	1.2		1.6	6.9	234.55		1614.69	112		No		Yes
In-flight	5.3	0.5	0.6			13.05	197	80	375.5			Yes - 21.05	No	No

[168] Data missing due to wheel column breaking during flight.
[169] Data missing due to severe thunderstorms that required use of ground simulation mode only.
[170] Data missing due to severe thunderstorms that required use of ground simulation mode only.

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 Degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude Deviation (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recovered[167]
In-flight	1.6	0.95	1.25		2	5.45	237.16		875.51			No		Yes
In-flight		1.15	1.3		1.84		175		382.5			Yes - 9.90	No	No
In-flight	1.85	0.4	0.9	1.85		1.65	164		67.5			Yes - 5.15	Yes	No
In-flight	-0.35	1.35	1.45	5	1.8	5	186.5		71.42			Yes - 7.60	Yes	No
In-flight[171]														

[171] Data missing due to wheel column breaking during flight.

Table 67. Group Mean and Standard Deviation for Performance Data for Detroit

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to First Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude/Heading Change (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery	Recover
No Aero/No Upset														
Mean	3.413	0.938	1.219	3.55	2.775	4.493	210.326	66.000	558.520	86.000	0 out of 8	16.990	0 out of 8	3 out of 8
Standard Deviation	1.961	0.166	0.227		1.794	3.377	22.618	5.657	440.872			5.235		
N	4	8	8	1	6	7	8	2	8	1		5	0	3
Aero/No Upset														
Mean	2.133	1.538	1.631	0 out of 8	3.397	4.210	196.284	0 out of 8	494.090	0 out of 8	0 out of 8	7.367	1 out of 8	4 out of 8
Standard Deviation	0.592	1.566	1.669		3.147	5.228	25.339		775.144			5.757		
N	3	8	8		6	5	7		7	0		3	1	4
No Aero/Upset														
Mean	5.180	0.950	1.117	2.3	5.253	3.538	226.508	0 out of 6	898.032	94.000		9.575	1 out of 6	2 out of 8
Standard Deviation	5.447	0.114	0.151		5.992	1.186	23.587		464.905			5.551		
N	5	6	6	1	4	4	5		5	1		2	1	2
Aero/Upset														
Mean	4.850	1.100	1.221	0 out of 7	1.910	9.507	218.690	0 out of 7	1083.738	0 out of 7	0 out of 7	12.925	1 out of 7	5 out of 8
Standard Deviation	4.746	0.253	0.847		0.657	14.509	23.594		328.037			5.339		
N	7	7	7	0	5	7	7		6	0		2	1	5
In-flight														
Mean	4.380	0.871	1.107	3.425	1.708	6.410	201.936	80.000	694.641	112.000		13.320	2 out of 7	2 out of 8
Standard Deviation	5.489	0.335	0.285	2.227	0.269	4.180	28.967		641.578			8.104		
N	5	7	7	2	5	5	7	2	7	1		5	2	2

Table 68. Group Mean and Standard Deviation for Recovery Data for Detroit[172]

Group	Time to Announce Problem (sec)	Time to Correct Aileron Input (sec)	Time to Correct Rudder Input (sec)	Time to First Correct Throttle Split (sec)	Time to Correct Elevator Input (sec)	Time to Correct Throttle Input (sec)	Max Airspeed (KIAS)	Time to Set Flaps Back to 20 degrees (sec)	Altitude Lost (ft)	Time to Inform ATC of Altitude/Heading Change (sec)	Time to Troubleshoot Deice System (sec)	Safety Trip	Safety Trip Affect Recovery
Recovery													
Mean	4.670	1.272	1.509		3.285	7.014	[redacted]	62	853.583	103.000		[redacted]	[redacted]
Standard Deviation	4.197	1.103	1.242		3.658	10.500	25.753		602.529	12.728			
N	15	16	16		14	14	16	1	16	2			
No Recovery													
Mean	3.528	0.948	1.083	3.175	2.512	4.789	[redacted]	75.000	595.561	86.000		[redacted]	[redacted]
Standard Deviation	4.414	0.285	0.272	1.413	1.737	3.822	22.403	7.071	522.391				
N	9	20	20	4	12	14	18	2	17	19			

[172] Shading indicates significant difference.

Two sets of analyses were performed – those to evaluate the effects of different types of training and those to identify differences in performance between evaluation pilots who recovered and the evaluation pilots who did not. Each of these is discussed in a separate section below.

5.3.8.1 Training Effects

Note that the results are discussed in the order of the recovery procedure steps and the variables used to quantify how well the evaluation pilots performed these steps.

5.3.8.1.1 Announce problem

There was no significant difference between groups in time to announce the problem ($F(4, 19) = 0.285$, $p = 0.884$).

5.3.8.1.2 Angle of attack should be reduced

There were no significant differences in the time to make the correct control inputs (aileron ($F(4, 31) = 0.939$, $p = 2.679$), rudder ($F(4, 31) = 0.441$, $p = 0.778$), or throttle ($F(4, 23) = 0.542$, $p = 0.706$). Only four evaluation pilots correctly used throttle split (1 out of 8 in No Aero/No Upset group, 1 out of 6 in No Aero/Upset group, and 2 out of 7 in the In-flight group).

5.3.8.1.3 Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed

There was no significant difference among groups in time to make the first correct elevator input ($F(4, 21) = 1.069$, $p = 0.397$) or in maximum airspeed ($F(4, 29) = 1.473$, $p = 0.236$)

5.3.8.1.4 Flaps may be set to 20°, speed permitting

Only three of the evaluation pilots returned flaps back to 20 degrees (2 in No Aero/No Upset group and 1 in In-flight group).

5.3.8.1.5 Return to starting altitude/heading

There was no significant difference in altitude lost ($F(4, 28) = 1.206$, $p = 0.330$) among the five training groups.

5.3.8.1.6 Inform ATC

Only three evaluation pilots informed ATC of the change in heading and/or altitude (1 out of 8 in No Aero/No Upset group, 1 out of 6 in No Aero/Upset group, and 1 out of 7 in In-flight group).

5.3.8.1.7 Troubleshoot deice system

None of the evaluation pilots started to troubleshoot the deicing system.

5.3.8.1.8 Safety trips and comments

Seventeen safety trips occurred across the five groups. The distribution was not significant by group, however ($F(4, 12) = 1.196$, $p = 0.362$). Five of them affected

recovery (1 out of 8 in Aero/No Upset group, 1 out of 6 in No Aero/Upset group, 1 out of 7 in Aero/Upset group, 2 out of 7 in In-flight group).

There were extensive comments during the flight regarding these recoveries. These comments are presented in Table 69. There were a large number of times in which the SP took control of the aircraft.

Table 69. Comments on Airplane Upset Recovery Performance Data for Detroit

Group	Safety Trip	Safety Trip Affect Recovery	Recover	Comments
No Aero/No Upset	Yes - 23.1	No	No	VSS trip on drdot and das. Pretty sporty ride. No need for "ATC" to request turn during scenario.
No Aero/No Upset	Yes - 10.15	No	No	SP took control during upset.
No Aero/No Upset	No	N/A	Yes	EP recovered. SP took control after event complete.
No Aero/No Upset	Yes - 14.10	No	No	VSS trip on drdot and das during upset. Initial upset occurred just as EP called for flaps down. EP immediately called for flaps back up. EP recognized structural icing.
No Aero/No Upset	Yes - 21.10	No	No	Good maneuver. VSS trip on das. EP got the aircraft heading downhill but pulled back which exacerbated the situation.
No Aero/No Upset	No	N/A	Yes	Powered up and accelerated through 210 KIAS to recover.
No Aero/No Upset	No	N/A	Yes	EP requested flaps down then up after upset appeared to correlate with moving the flaps (Lear flaps were not moved). Finally pushed power up. 220 KIAS when SP took control with maneuver complete.
No Aero/No Upset	Yes - 16.50	No	No	No turn call from ATC required. VSS trip on das and drdot. EP appeared to have control once before losing control again.
Aero/No Upset	No	N/A	Yes	EP got into upset before "ATC" turn call.
Aero/No Upset	No	N/A	Yes	SP took control after event complete. No need for "ATC" to request turn during scenario.
Aero/No Upset	No	N/A	No	VSS trip on des and das during upset. Roll excursions went on for quite awhile before VSS trip. EP "couldn't figure it out" although power was pushed up once.
Aero/No Upset	Yes - 2.45	Yes	No	VSS trip on dadot and das on first roll upset. EP made big roll input.
Aero/No Upset	Yes - 13.70	No	No	VSS trip on drdot as EP was using rudder to help roll during upset. No turn call from ATC required to initiate upset.
Aero/No Upset	No	N/A	Yes	EP called for max thrust to recover.
Aero/No Upset	Yes - 5.95	No	No	Good recovery. EP added power immediately. SP then pulled power back before VSS trip on deltaAs & deltaPa during roll input.
Aero/No Upset	No	N/A	Yes	Good recovery. Nice and smooth on the controls. Lower nose to get 230 KIAS followed by a gentle pull up. No power change.
No Aero/Upset	No	N/A	Yes	None
No Aero/Upset	No	N/A	No	None
No Aero/Upset	No	N/A	Yes	EP added power. Responded to ATC's call to slow to 150 KIAS with "that's not going to work." 230 KIAS at recovery.
No Aero/Upset	Yes - 5.65	Yes	No	SP took control at ~135 deg of right bank after one roll excursion to the left. EP used differential thrust to recover from left roll but never took it back out when aircraft rolled right.
No Aero/Upset	No	N/A	No	No power change initially. Pushed power up and V=225 KIAS while in upset when VSS tripped on Ny. No recovery.
No Aero/Upset	Yes - 13.50	No	No	EP said, "I've lost control." EP started to recover as airspeed was increasing in dive, then pulled and stalled wing again. No power change. SP took control in dive.
No				

Group	Safety Trip	Safety Trip Affect Recovery	Recover	Comments
Aero/Upset				
No Aero/Upset				
Aero/Upset	No	N/A	Yes	
Aero/Upset	No	N/A	Yes	EP increased airspeed to > 200 KIAS. EP reduced power initially then brought some back in.
Aero/Upset	No	N/A	Yes	EP powered up to recover from very first upset. EP didn't worry about altitude loss. 214 KIAS as SP took control after recovery was complete.
Aero/Upset	Yes - 16.70	No	No	No throttle change. SP took control in upset.
Aero/Upset	No	N/A	Yes	Good recovery. VSS trip on das and dPA.
Aero/Upset	No	N/A	Yes	242 KIAS during recovery. EP didn't hold altitude ("didn't care").
Aero/Upset	Yes - 9.15	Yes	No	EP called for max power. VSS trip on drdot and das. No recovery.
Aero/Upset				
In-flight	Yes - 22.90	No	No	V=214 KIAS with significant roll oscillations. EP did not recover.
In-flight	No	N/A	Yes	EP added some power, permitted descent to 3500 ft MSL, V=223 KIAS to successfully recover. Asked SP to tell ATC they can't hold altitude.
In-flight	Yes - 21.05	No	No	EP called for max power and flaps back to where they were. VSS trip on das and des during upset.
In-flight	No	N/A	Yes	EP applied max power and flew out of upset at V=230 KIAS. Good, long upset.
In-flight	Yes - 9.90	No	No	EP disconnected automation quickly. SP took control in upset with phi = +110 deg.
In-flight	Yes - 5.15	Yes	No	EP powered up immediately. VSS trip on dadot, das, deltaPa during upset early in maneuver.
In-flight	Yes - 7.60	Yes	No	EP split power during roll left (power up on left engine). EP didn't pull power back as A/C rolled right resulting in large bank angle from which SP took control.
In-flight				

5.3.8.2 Recovery Differences

Comparisons were also made between the performance of evaluation pilots who recovered and those who did not. There was no significant difference between these groups in time to announce the problem ($F(1, 22) = 0.401$, $p = 0.533$). Nor were there are significant differences in time to make correct control inputs (aileron ($F(1, 34) = 1.607$, $p = 0.214$), rudder ($F(1, 34) = 2.243$, $p = 0.143$), elevator ($F(1, 24) = 0.448$, $p = 0.510$), throttle ($F(1, 26) = 0.555$, $p = 0.463$)). Only four evaluation pilots made correct throttle splits prior to correct elevator input. All four were in the group of evaluation pilots who did not recover.

Like the Roselawn evaluation scenario, the evaluation pilots who recovered had significantly higher max airspeed (220 KIAS) than those who did not (201 KIAS) ($F(1, 32) = 5.568$, $p = 0.025$). However, only three evaluation pilots (2 in the no recovery and 1 in the recovery group) set flaps back to 20 degrees. Further, only three evaluation pilots (1 in the no recovery and 2 in the recovery group) informed ATC of an altitude or heading change. None of the evaluation pilots troubleshot the deicing system. Nor was there a significant difference in altitude lost during recovery ($F(1, 31) = 1.734$, $p = 0.198$).

Again like the Roselawn evaluation scenario, there were significantly more safety trips for the evaluation pilots who did not recover (17) than for those who did (0) (χ^2 (1) = 25.768, $p \leq 0.001$). There was also a significant difference in groups for the safety trips that affected recovery (0 recovery group, 5 no recovery group) (χ^2 (1) = 4.645, $p \leq 0.050$). These safety trips occurred when the evaluation pilot failed to make appropriate initial responses.

5.3.9 Comparisons Across Scenarios

The previous sections describe the performance recovery results separately by scenario since the recovery procedures for each scenario was different. However, some experts have suggested that there would be a significant association between the percent of evaluation pilots who recovered in each scenario and the type of training the evaluation pilots received. That was not the case ($\chi 2$ (28) = 3.511, $p \leq 1.000$)(see Table 70). A two-factor anova without replication was calculated to assess the main effects of scenario and training group. There was no significant effect of training group (F (4, 39) = 0.955, p = 0.447). The effect of scenario was significant, however, F (7, 39) = 14.937, p = 0.000). The results are plotted in Figure 28. The highest portion of pilots recovered from the Charlotte scenario, the smallest from Shemya.

Table 70. Portion Evaluation Pilots Who Recovered By Scenario and Training Group

	Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
No Aero/No Upset	0.125	1.000	0.125	0.375	1.000	0	0.333	0.375
Aero/No Upset	0	0.750	0.125	0.250	1.000	0.125	0.500	0.500
No Aero/Upset	0.166	1.000	0	0.500	1.000	0.166	0.143	0.250
Aero/Upset	000	1.000	0.143	0.143	1.000	0	0.286	0.625
In-flight	0.286	0.750	0.143	0.429	0.857	0.857	0.857	0.250
Scenario average	0.115	0.900	0.107	0.339	0.971	0.230	0.424	0.400

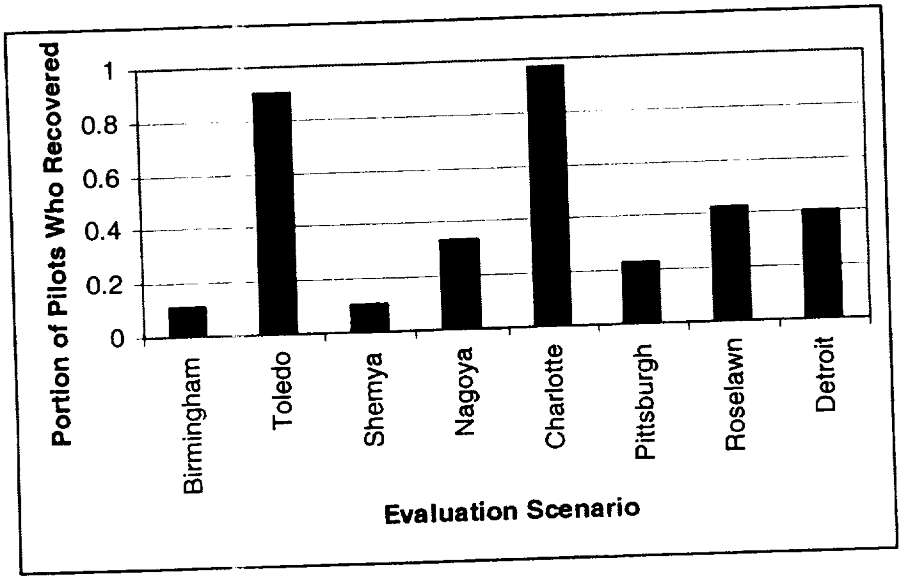

Figure 28. Effect of Scenario on Portion of Pilots Who Recovered

The percent recoveries made by each training group were compared across the three surprise scenarios (see Table 71). There was no significant association between training group and scenario.

Table 71. Portion Evaluation Pilots Who Recovered By Surprise Scenario and Training Group

	Birmingham	Nagoya	Pittsburgh
No Aero/No Upset	0	0	0
Aero/No Upset	0	75	33
No Aero/Upset		0	25
Aero/Upset	0	0	100
In-flight	100	33	50

Also of interest was the number of recoveries per pilot – regardless of training group. This distribution is presented in Figure 29. A pilot could recover from zero to eight of the evaluation scenarios. None of the pilots recovered from all eight scenarios. Two recovered from none, the majority from five of the eight scenarios.

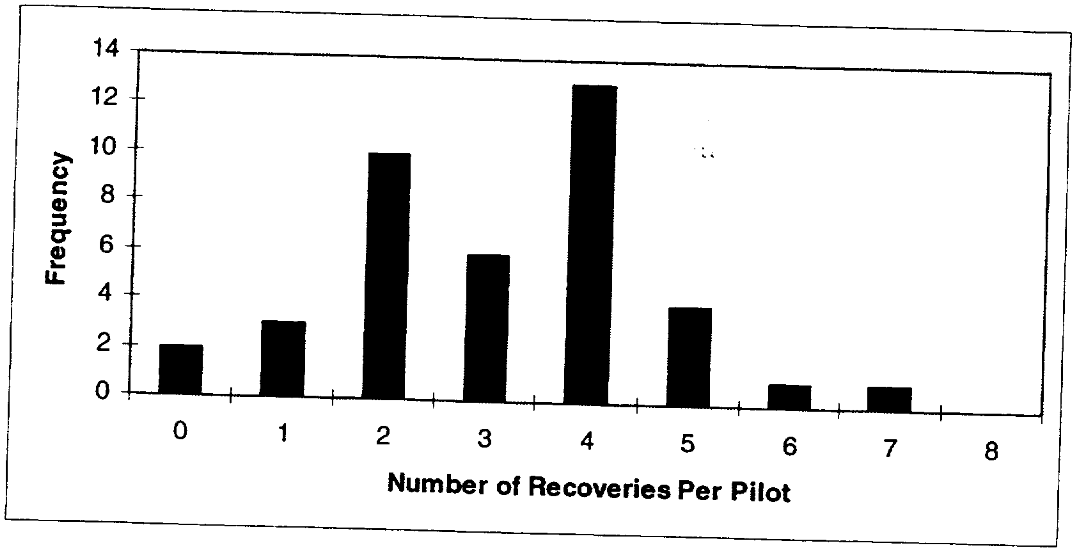

Figure 29. Number of Recoveries Per Pilot

Several other cross scenario comparisons were made with the following exceptions: time to first autopilot disengage was not used as a dependent variable for Birmingham or Toledo since very few of the evaluation pilots correctly disengaged the autopilot during these scenarios (e.g., none in Birmingham, five in Toledo).

Throttle data were not analyzed for Shemya since since this scenario did not require throttle input. However, in Birmingham and Nagoya where throttle was required, the evaluation pilots did not make any throttle inputs. In addition, evaluation pilots did not use bank angle in Nagoya so there was neither rudder (none of the evaluation pilots) nor aileron (only 17 evaluation pilots) input. Further only 15 of the evaluation pilots disengaged the autopilot. For Charlotte, none of the evaluation pilots disengaged the autopilot and only 10 made any elevator input. For Pittsburgh, only 3 evaluation pilots disengaged the autopilot, only 11 made throttle inputs, and only 20 elevator inputs. For Roselawn, none disengaged the autopilot, only 3 used the throttle, and only 17 used elevator. For Detroit, none disengaged the autopilot and only 4 made correct throttle inputs.

The independent variables for the remaining analyses were the evaluation pilot group (No aero/no upset, Aero/no upset, No aero/upset, Aero/upset, and In-flight) and evaluation scenario (Birmingham, Toledo, Shemya, Nagoya, Charlotte, Pittsburgh, Roselawn, and Detroit). All of the anova summary tables for performance times are presented in Table 72.

There was not a significant effect of training on time to first correct rudder input. However, there was a significant effect of scenario (Nagoya and Charlotte were not included since none of the evaluation pilots made rudder inputs, see Figure 30). Subsequent Scheffé post hoc analyses showed the first correct rudder input for the Toledo evaluation scenario was significantly longer than any of the other five scenarios.

Table 72. ANOVA and Summary Tables for Performance Times

First Correct Rudder (Primary -Pittsburgh, Secondary - Birmingham, Toledo, Shemya, Roselawn, Detroit Only)

Source of Variation	SS	df	MS	F	P-value	F crit
Scenario (S)	718.975	5	143.795	106.092	0.000	3.105
Training Group (T)	13.303	4	3.326	2.454	0.047	3.410
Interaction (S x T)	41.199	20	2.060	1.520	0.077	1.967
Within	284.629	210	1.355			
Total	1058.105	239				

Group	Statistic	No aero/no upset	Aero/no upset	No aero/upset	Aero/upset	In-flight
Birmingham	Average	0.508	0.592	0.438	0.333	0.368
	Variance	0.697	0.140	0.280	0.039	0.077
Toledo	Average	5.408	4.114	5.200	4.900	7.325
	Variance	3.570	0.466	1.867	2.680	24.961
Shemya	Average	2.119	2.081	2.058	2.014	2.193
	Variance	0.019	0.013	0.007	0.018	0.012
Pittsburgh	Average	0.536	0.521	0.331	0.900	0.629
	Variance	0.042	0.081	0.052	0.686	0.093
Roselawn	Average	1.214	0.388	0.514	0.190	0.679
	Variance	0.646	0.162	0.251	0.019	0.376
Detroit	Average	1.031	1.293	1.244	1.058	1.743
	Variance	0.111	0.417	0.172	0.005	2.706

First Correct Throttle (Toledo Only – Secondary Input)

Source of Variation	SS	df	MS	F	P-value	F crit
Between Training Groups	354.712	4	88.678	2.654	0.049	3.908
Within Training Groups	1169.352	35	33.410			
Total	1524.064	39				

Groups	*Average*	*Variance*
No aero/no upset	11.550	3.391
Aero/no upset	17.880	63.044
No aero/upset	14.641	47.087
Aero/upset	19.750	45.771
In-flight	13.430	7.757

First Correct Aileron (Primary - Birmingham, Toledo, Pittsburgh, Roselawn, Detroit Only, Secondary - Shemya)

Source of Variation	SS	df	MS	F	P-value	F crit
Scenario (S)	856.497	5	171.299	358.806	0.000	3.105
Training Group (T)	22.881	4	5.720	11.982	0.000	3.410
Interaction (S x T)	128.441	20	6.422	13.452	0.000	1.967
Within	100.257	210	0.477			
Total	1108.077	239				

Group	Statistic	No aero/no upset	Aero/no upset	No aero/upset	Aero/upset	In-flight
Birmingham	Average	0.364	0.271	0.325	0.068	0.241
	Variance	0.692	0.086	0.180	0.014	0.074
Toledo	Average	4.021	5.250	5.800	5.079	6.019
	Variance	0.353	2.094	1.984	1.449	1.533
Shemya	Average	2.479	2.239	6.050	5.378	1.700
	Variance	0.850	0.715	0.000	0.030	0.000
Pittsburgh	Average	0.700	0.721	0.737	0.909	0.807
	Variance	0.120	0.081	0.128	0.394	0.040
Roselawn	Average	0.561	0.031	0.092	0.000	0.308
	Variance	0.622	0.002	0.029	0.000	0.193
Detroit	Average	1.050	0.858	1.025	0.959	1.564
	Variance	0.046	0.035	0.068	0.114	2.398

First Correct Elevator (Birmingham, Toledo, Shemya, Nagoya, Detroit Only)

Source of Variation	SS	df	MS	F	P-value	F crit
Scenario (S)	342.270	4	85.568	40.120	0.000	3.428
Training Group (T)	6.749	4	1.687	0.791	0.532	3.428
Interaction (S x T)	47.704	16	2.981	1.398	0.147	2.105
Within	373.239	175	2.133			
Total	769.962	199				

Group	Statistic	No aero/no upset	Aero/no upset	No aero/upset	Aero/upset	In-flight
Birmingham	Average	4.354	3.800	4.914	4.033	4.000
	Variance	0.768	0.161	0.726	0.185	0.411
Toledo	Average	5.991	6.768	5.917	6.109	6.463
	Variance	1.336	3.275	1.805	2.222	0.915
Shemya	Average	6.050	5.219	5.950	5.058	4.464
	Variance	4.456	2.879	1.476	0.648	0.484
Nagoya	Average	2.915	3.239	2.720	2.792	2.664
	Variance	1.141	1.166	0.831	0.382	0.736
Detroit	Average	3.801	1.466	2.871	3.350	3.678
	Variance	18.645	0.196	2.086	2.912	3.474

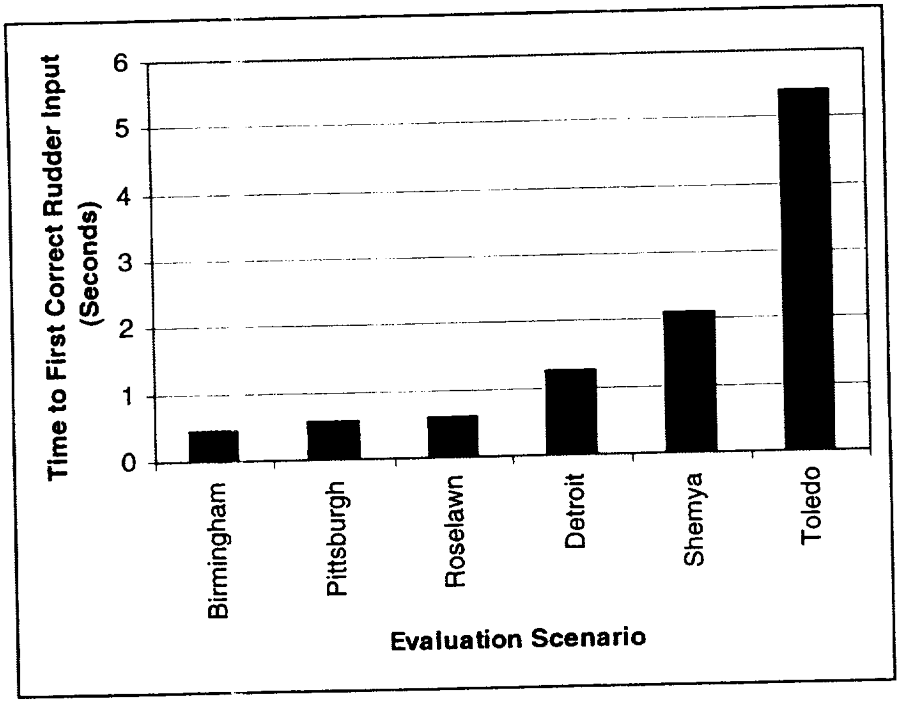

Figure 30. Significant Effect of Scenario on Time to First Correct Rudder Input (Secondary Input for Birmingham, Roselawn, Detroit, Shemya, Toledo)

There was no significant effect of training on time to first correct throttle input (Shemya was not included since it did not require throttle input for recovery; Charlotte since it used time to definitive thrust change rather than time to first correct throttle input; Birmingham and Nagoya since evaluation pilots did not make any throttle inputs; and Pittsburgh, Roselawn, and Detroit since only 11 or fewer evaluation pilots made throttle inputs in these scenarios).

For first correct aileron, the two main effects (training and scenario) as well as their interaction were significant. In keeping with conservative statistical procedures, only the interaction was reviewed. The clearest differences in training occurred for Shemya (see Figure 31). For this scenario, upset training in the simulator was associated with longer times to first correct aileron input, a secondary response.

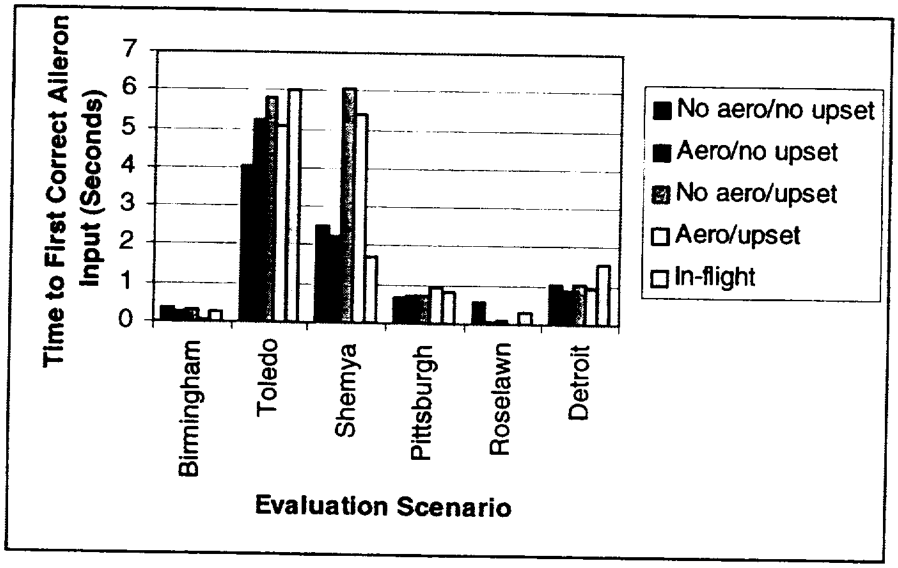

Figure 31. Significant Interaction of Training by Scenario on Time to First Correct Aileron Input (Secondary Input for Shemya)

There was a significant scenario effect on time to first correct elevator input (Charlotte was not included since only 10 evaluation pilots made any elevator input; Pittsburgh only 20 evaluation pilots; Roselawn only 17; see Figure 32). Subsequent Scheffé post hoc analyses indicated that time to first correct elevator input was significantly longer for the Toledo scenario than for Nagoya or Detroit.

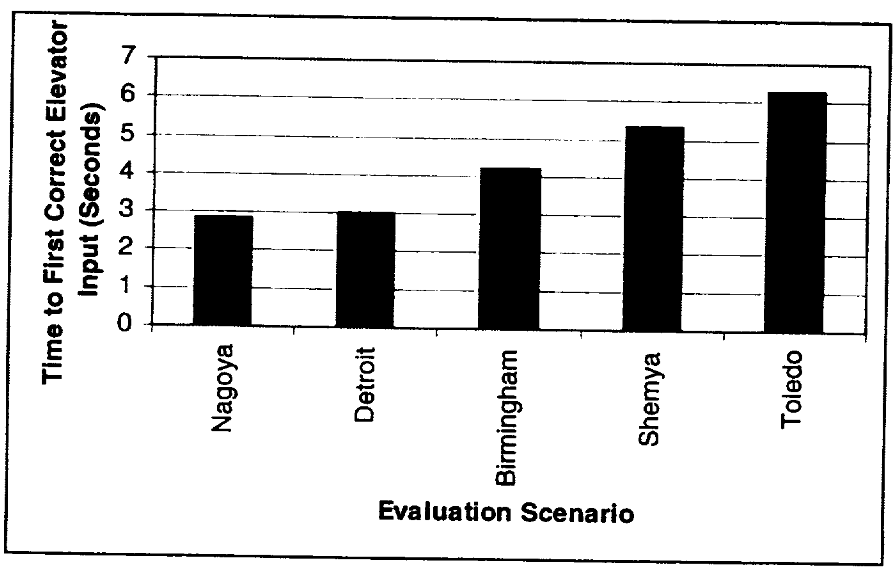

Figure 32. Significant Effect of Scenario on Time to First Correct Elevator Input (Secondary Input for Toledo)

The number of correct recovery responses made in each scenario was converted to percent and an anova calculated with two independent variables: group (No aero/no upset, Aero/no upset, No aero/upset, Aero/upset, and In-flight) and evaluation scenario

(Birmingham, Toledo, Shemya, Nagoya, Charlotte, Pittsburgh, Roselawn, and Detroit). Data for one step, "cross check instruments", in one scenario, Toledo, was omitted since this could not be reliably measured in-flight. Data for "recognize PIO tendency" and "investigate problem" in the Shemya scenario were likewise omitted for the same reason. As was "attitude crosscheck" for the Pittsburgh scenario. The anova summary table is presented in Table 73. The independent variables for this analysis were training group (No aero/no upset, Aero/no upset, No aero/upset, Aero/upset, and In-flight) and evaluation scenario (Birmingham, Toledo, Shemya, Nagoya, Charlotte, Pittsburgh, Roselawn, and Detroit). Here, there was a significant scenario effect (see Figure 33). Three other anovas were calculated using the same independent variables. The dependent variables were first correct pitch, roll, and throttle inputs. The summary tables are included in Table 73. There was a significant effect of scenario on pitch (see Figure 34). There was a significant interaction of training type and scenario on roll inputs (see Figure 35) and a significant scenario effect on throttle inputs (see Figure 36).

Table 73. ANOVA and Summary Tables for Recovery Actions

Percent Correct Recovery Actions

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Scenario (S)	0.663	7	0.095	35.532	0.000	3.358
Training (T)	0.029	4	0.007	2.734	0.049	4.074
Error	0.075	28	0.003			
Total	0.767	39				

Scenario	*Average*	*Variance*
Birmingham	0.488	0.009
Toledo	0.679	0.001
Shemya	0.319	0.001
Nagoya	0.489	0.002
Charlotte	0.436	0.001
Pittsburgh	0.456	0.002
Roselawn	0.239	0.007
Detroit	0.308	0.002
Training		
No aero/no upset	0.427	0.015
Aero/no upset	0.468	0.017
No aero/upset	0.440	0.018
Aero/upset	0.389	0.027
In-flight	0.408	0.029

Average Number of Correct Pitch Inputs

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Scenario (S)	31.523	7	4.503	54.317	0.000	2.704
Training (T)	0.015	4	0.004	0.046	0.996	3.387
Interaction (S x T)	2.776	28	0.099	1.196	0.233	1.793
Within	23.214	280	0.083			
Total	57.527	319				

Group	Statistic	Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
Aero/No Upset	Average	1.000	1.000	1.000	0.000	0.000	1.000	0.625	1.000
	Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.268	0.000
Aero/Upset	Average	1.000	1.000	1.000	0.000	0.000	1.000	0.190	1.000
	Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.000
In-flight	Average	1.000	1.000	1.000	0.000	0.000	1.000	0.579	1.000
	Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.199	0.000
No Aero/No Upset	Average	0.750	1.000	1.000	0.000	0.000	1.000	0.895	1.000
	Variance	0.214	0.000	0.000	0.000	0.000	0.000	0.142	0.000
No Aero/Upset	Average	0.750	1.000	1.000	0.000	0.000	1.000	0.439	1.000
	Variance	0.214	0.000	0.000	0.000	0.000	0.000	0.109	0.000

Average Number of Correct Roll Inputs

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Scenario (S)	56.035	7	8.005	274.523	0.000	2.704
Training (T)	0.221	4	0.055	1.895	0.112	3.387
Interaction (S x T)	2.518	28	0.090	3.084	0.000	1.793
Within	8.165	280	0.029			
Total	66.939	319				

Group	Statistic	Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
Aero/No Upset	Average	1.000	1.000	1.000	1.000	0.250	0.375	0.500	1.000
	Variance	0.000	0.000	0.000	0.000	0.214	0.268	0.286	0.000
Aero/Upset	Average	1.000	1.000	1.000	1.000	0.250	0.375	0.375	1.000
	Variance	0.000	0.000	0.000	0.000	0.214	0.268	0.268	0.000
In-flight	Average	1.000	1.000	1.000	1.000	0.500	0.500	0.100	1.000
	Variance	0.000	0.000	0.000	0.000	0.286	0.286	0.080	0.000
No Aero/No Upset	Average	1.000	1.000	1.000	1.000	0.125	0.500	0.538	1.000
	Variance	0.000	0.000	0.000	0.000	0.125	0.286	0.254	0.000
No Aero/Upset	Average	1.000	1.000	1.000	1.000	0.000	0.750	0.375	1.000
	Variance	0.000	0.000	0.000	0.000	0.000	0.214	0.268	0.000

Average Number of Correct Throttle Inputs

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Scenario (S)	32.852	7	4.693	86.483	0.000	2.704
Training (T)	0.317	4	0.079	1.460	0.215	3.387
Interaction (S x T)	2.488	28	0.089	1.637	0.025	1.793
Within	15.195	280	0.054			
Total	50.851	319				

Group	Statistic	Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
Aero/No Upset	Average	0.000	1.000	0.000	0.000	0.000	0.500	0.000	0.000
	Variance	0.000	0.000	0.000	0.000	0.000	0.286	0.000	0.000
Aero/Upset	Average	0.000	1.000	0.000	0.000	0.000	0.125	0.125	0.481
	Variance	0.000	0.000	0.000	0.000	0.000	0.125	0.125	0.510
In-flight	Average	0.000	1.000	0.000	0.000	0.000	0.250	0.000	0.000
	Variance	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000
No Aero/No Upset	Average	0.000	1.000	0.000	0.000	0.000	0.250	0.000	0.000
	Variance	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000
No Aero/Upset	Average	0.000	1.000	0.000	0.000	0.000	0.250	0.250	0.375
	Variance	0.000	0.000	0.000	0.000	0.000	0.214	0.214	0.268

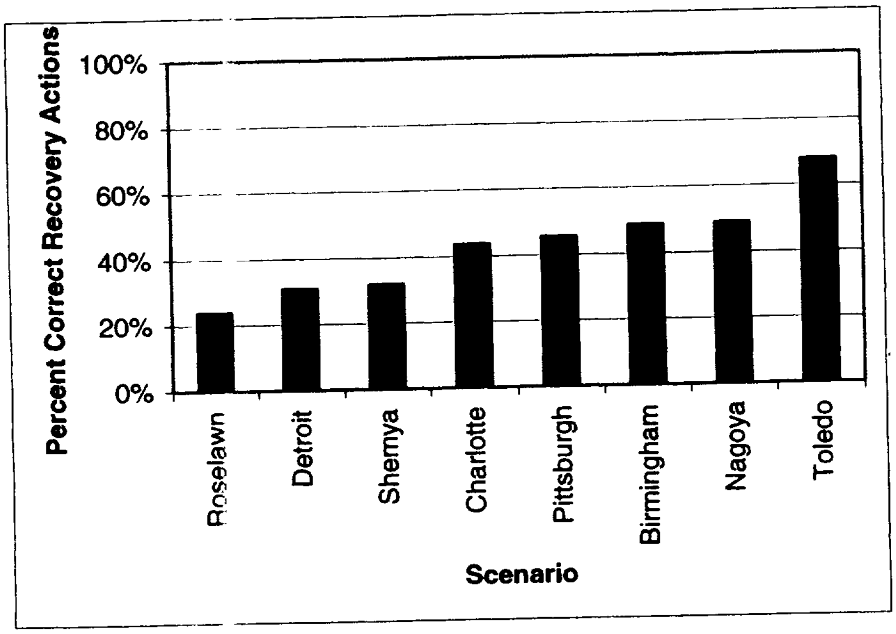

Figure 33. Significant Effect of Scenario on Percent Correct Recovery Actions

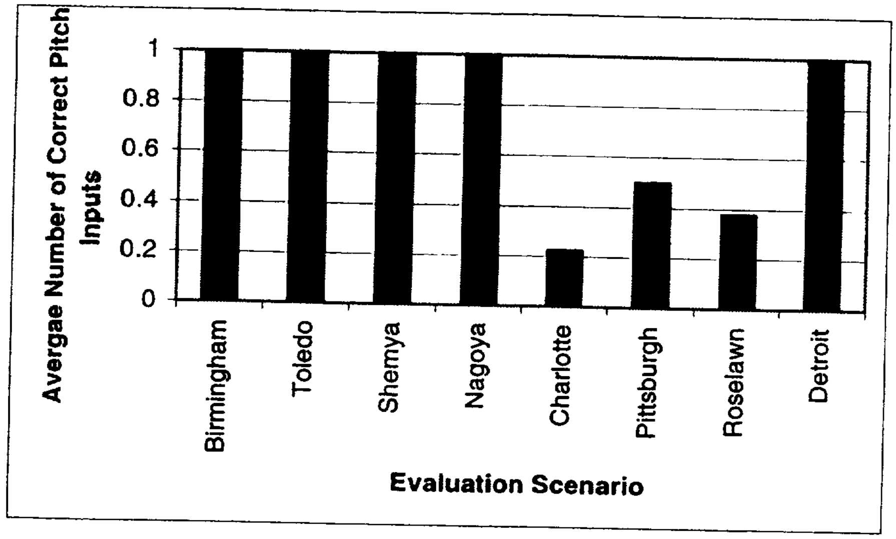

Figure 34. Significant Effect of Scenario on Number of Correct Pitch Inputs

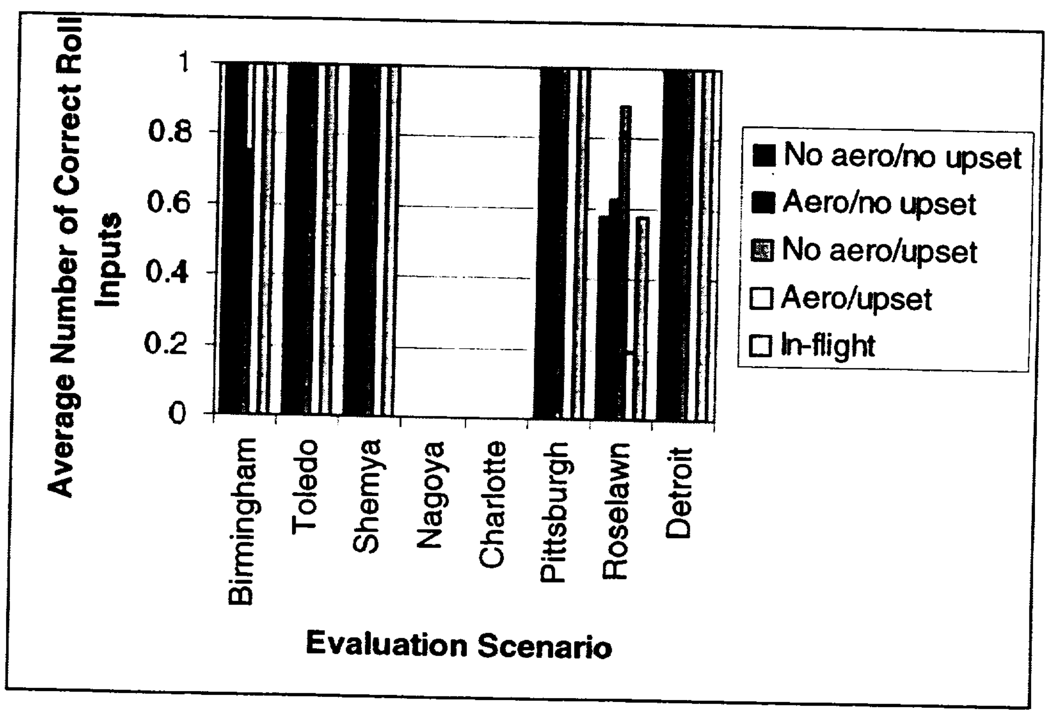

Figure 35. Significant Interaction of Training and Scenario on Average Number of Correct Roll Inputs

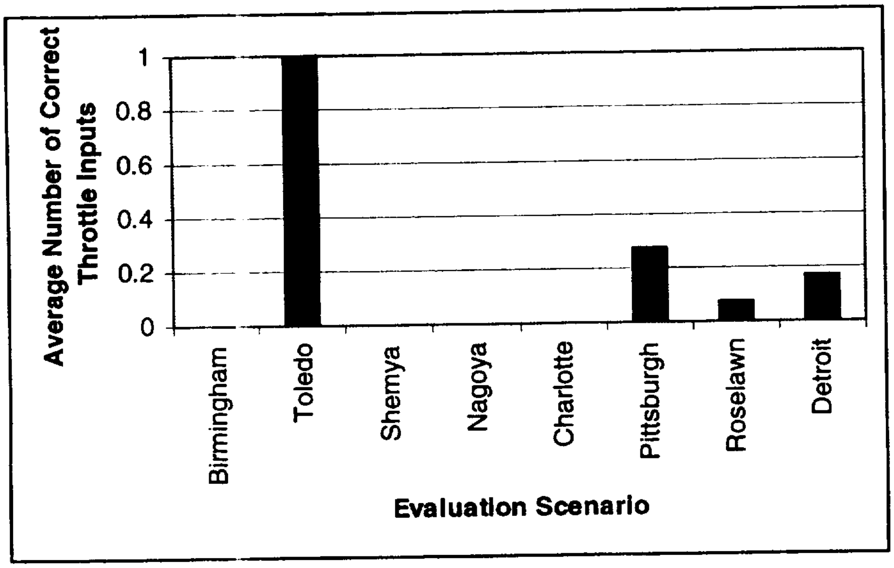

Figure 36. Significant Effect of Scenario on Average Number of Correct Throttle Inputs

5.3.10 Missing Data

Some anomalies in data gathering occurred. Due to severe thunderstorms during their scheduled test period, 2 of the 40 evaluation pilots flew the upset scenarios in the ground simulation mode of the Learjet only. Ground simulation mode is the mode in which the variable stability Learjet is used as a fixed, ground-based simulator. The VSS is up and running and the evaluation pilot is "flying" the simulated aircraft using the same control inceptors as when in the air. Sensor signals to the VSS computer are simulated. The control surface position signals are sent to the VSS computer as the surfaces move in response to pilot and computer inputs. Aircraft motion is indicated on the multi-function display, providing the evaluation pilot with visual feedback of aircraft response. Every VSS maneuver flown in the air can be simulated on the ground in this mode. One had both aerobatic and upset training, the other only upset training. Their data were not analyzed with the in-flight data due to differences in visual and motion cues. During two of the flights, technical malfunction in the simulation wheel column (i.e., broken cables due to the force of the evaluation pilot's input) occurred after four scenarios. Finally during a third flight the simulation autopilot was not correctly reset causing anomalies in the initial flight conditions.

5.3.11 Safety Trips

During planning of this airplane upset training evaluation, concern was voiced that the safety trips in the in-flight simulator might interfere with the recovery performance of the evaluation pilots. There were two sources of the safety trips – automatic and safety pilot induced. The automatic safety trips protected the aircraft from exceeding a structural or flight envelope limit such as g or angle of attack. The safety pilot was instructed to limit the airplane to stay within reasonable safe attitude, airspeed, and altitude. The safety pilot trips that did occur were considerably after the evaluation pilot's first input was recorded.

Whether or not a safety trip affected a given recovery depended on the amount of time the pilot had to recover prior to the trip. The VSS trip DID NOT affect the recovery if the EP had sufficient time to affect a recovery prior to the trip. For instance, several of the Nagoya scenarios resulted in a VSS trip on AOA after the EP pushed forward on the yoke for a period of time without banking the aircraft or requesting emergency trim. The VSS trip DID affect the recovery if the trip prevented the pilot from having enough time to recover. For instance, there were several Birmingham scenarios in which the VSS tripped almost immediately during the pitch-up portion of the upset. The VSS trip prevented the EP from having a reasonable opportunity to recover from the upset and was therefore considered to have affected the recovery.

An analysis of variance was calculated on the total number of safety trips. This analysis included both automatic and safety pilot commanded trips. The independent variables for this analysis were training group (No aero/no upset, Aero/no upset, No aero/upset, Aero/upset, and In-flight) and evaluation scenario (Birmingham, Toledo, Shemya, Nagoya, Charlotte, Pittsburgh, Roselawn, and Detroit). There was no significant effect of training but there was a significant scenario effect (see Figure 37). The comments made by evaluation pilots during the debriefs are listed in Appendix M.

Table 74. ANOVA Table for Safety Trips

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Scenario (S)	424.800	7	60.686	126.335	0.000	3.358
Training (T)	1.350	4	0.338	0.703	0.597	4.074
Error	13.450	28	0.480			
Total	439.600	39				

Group	Average	Variance
Birmingham	2.400	1.300
Toledo	1.000	0.000
Shemya	7.200	0.200
Nagoya	8.000	0.000
Charlotte	0.200	0.200
Pittsburgh	8.000	0.000
Roselawn	1.000	0.500
Detroit	1.000	1.500
Training		
No aero/no upset	3.750	13.929
Aero/no upset	3.500	12.286
No aero/upset	3.875	10.982
Aero/upset	3.500	12.286
In-flight	3.375	13.125

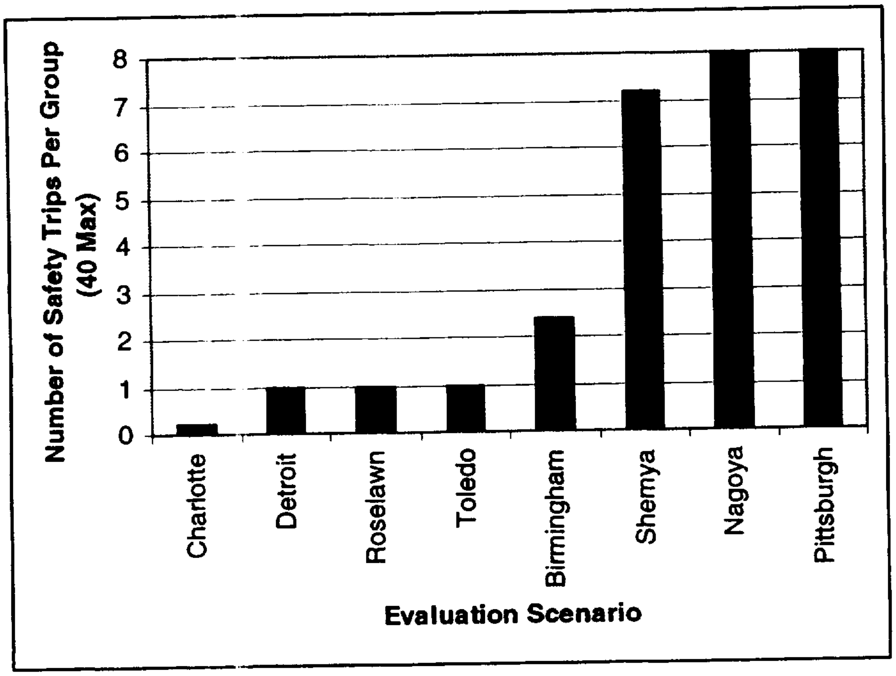

Figure 37. Significant Effect of Scenario on Number of Safety Trips

The large number of analyses without significant differences was also of concern. Therefore, a statistical power analysis was performed on typical results indicating power was equal to about 74%. This is lower than the statistical power calculated from the military pilots in a previous study. A potential reason for this difference is the higher emphasis on standardization in both training and execution for military pilots.

5.4 SAFETY PILOT RATINGS

The mean and standard deviations of the Safety Pilot ratings are presented in Table 75 by training group. Four anovas were calculated for the safety pilot rating. The factor was group (see Table 75). There were no significant differences among groups in any of the safety pilot ratings although safety pilot ratings were highest for the in-flight training group on all rating scales. Definitions of the dimensions of the Safety Pilots Rating Scale are presented in section 4.3.5. Safety pilot ratings were designed to capture the overall understanding, approach, and implementation skills of the evaluation pilot. It would be impossible to provide valid ratings on each scenario due to lack of repetition on each scenario therefore an overall rating was provided. Given the population of the evaluation pilots it is not surprising that safety pilot ratings did not show a significant difference. This matches the results of performance data.

Table 75. Mean and Standard Deviation of Four Safety Pilot Ratings By Training Group

Control Safety Pilot Rating		
Groups	Average	SD
No Aero/No Upset	2.875	1.246
No Aero/Upset	2.125	0.834
Aero/No Upset	2.875	1.246
Aero/Upset	2.875	1.126
In-flight	3.375	0.916
Anticipation and Situational Awareness Safety Pilot Rating		
Groups	Average	SD
No Aero/No Upset	2.625	1.188
No Aero/Upset	2.500	1.309
Aero/No Upset	3.125	0.991
Aero/Upset	2.875	1.126
In-flight	3.375	0.916
Comprehension Safety Pilot Rating		
Groups	Average	SD
No Aero/No Upset	3.000	1.195
No Aero/Upset	2.750	0.886
Aero/No Upset	2.750	0.707
Aero/Upset	2.750	0.707
In-flight	3.625	0.916
Overall Safety Pilot Rating		
Groups	Average	SD
No Aero/No Upset	3.375	1.188
No Aero/Upset	3.375	0.916
Aero/No Upset	3.625	0.744
Aero/Upset	3.375	0.916
In-flight	3.625	0.916

Table 76. ANOVA and Summary Tables for Safety Pilot Ratings

Control (1 = large excursions to 5 = precision)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	6.400	4	1.6	1.353	0.270	2.641
Within Groups	41.375	35	1.182			
Total	47.775	39				

Groups	*Average*	*Variance*
No Aero/No Upset	2.875	1.554
No Aero/Upset	2.125	0.696
Aero/No Upset	2.875	1.554
Aero/Upset	2.875	1.268
In-flight	3.375	0.839

Anticipation (1 = large corrections to 5 = very few inputs)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	4.100	4	1.025	0.825	0.518	2.641
Within Groups	43.500	35	1.243			
Total	47.600	39				

Groups	*Average*	*Variance*
No Aero/No Upset	2.625	1.411
No Aero/Upset	2.500	1.714
Aero/No Upset	3.125	0.982
Aero/Upset	2.875	1.268
In-flight	3.375	0.839

Comprehension (1 = no change over flight to 5 = improves over flight)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	4.600	4	1.151	1.419	0.248	2.641
Within Groups	28.375	35	0.811			
Total	32.975	39				

Groups	*Average*	*Variance*
No Aero/No Upset	3.000	1.429
No Aero/Upset	2.750	0.786
Aero/No Upset	2.750	0.500
Aero/Upset	2.750	0.500
In-flight	3.625	0.839

Overall (1 = constant monitoring to 5 = instill confidence)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	0.600	4	0.15	0.167	0.954	2.641
Within Groups	31.375	35	0.896			
Total	31.975	39				

Groups	*Average*	*Variance*
No Aero/No Upset	3.375	1.411
No Aero/Upset	3.375	0.839
Aero/No Upset	3.625	0.554
Aero/Upset	3.375	0.839
In-flight	3.625	0.839

5.5 AIRPLANE UPSET TRAINING EVALUATION RESULTS WORKSHOP

The purpose of this second workshop was to coordinate a focused review of the report, results, and recommendations. This second workshop was held on 8 January 2002 and was hosted by the Air Line Pilots Association. Eighteen people representing 9 different organizations participated in the workshop (see Table 77). Another 4 people were sent the draft report and executive summary for comment.

Table 77. Results Workshop Participants

Name	Affiliation
Rockliff, Larry	Airbus
Baum, Chris	ALPA
Bracken, Joe	ALPA
Corrie, Steve	ALPA
Cox, John	ALPA
Lutz, Terry	ALPA
Penney, John	ALPA
Reed, Chris	ALPA
Sumwalt, Robert	ALPA
Vanderburgh, Warren	American Airlines
Cashman, John	Boeing
Joyce, Doug	Daniel Webster College
Foster, Jim	FAA
White, John	NASA
Berman, Ben	San Jose State University Foundation/NASA Ames
Bobbitt, Rick	United Airlines
Gawron, Valerie	Veridian Engineering
Peer, Jeff	Veridian Engineering

The slides used for the workshop as well as the comments made during the discussion of each slide is presented in Appendix O. After the scheduled agenda, each participant was asked to summarize his recommendations for the next steps. Recommendations that differed from those presented in the recommendations section of this report are presented below:

1. The data show the need for improving airplane upset recovery training. Further research is needed to identify effective improvements.

2. Train prioritization of use of primary and then secondary controls.

3. Train pilots to recognize when the aircraft has stalled and how to recover from a stall. Specifically, implement validated aero packages in the simulators used for post stick shaker (not approach to stall) training. Teach approach to stall with and without thrust. Demonstrate stalls with power off or nose low. Measure frequency and effect of simulator sickness due to increased motion. Further, teach that one stall recovery technique may not apply to all scenarios (e.g., wing ice induced stall, tail plane, aerodynamic stall).

4. Determine whether airplane upset recovery training will reduce the cost (i.e., time) of simulator training in more mundane maneuvers such as engine out and other aircraft control tasks.

5. Identify what information is needed by pilots to recover from an airplane upset. Evaluate effectiveness of AOA and g meters on flight decks to aid

in airplane-upset recoveries. If effective, develop, test, and consider mandating an angle of attack display and g meter on the flight deck.

6. Emphasize airplane-upset avoidance and train airplane upset recovery. This is especially critical for high altitude recoveries. Demonstrate handling qualities at high altitude, high altitude stalls, and the difference between high-speed buffet and stall.

7. There should be a dual-pronged approach to minimizing upsets. First, improve the quality of upset recovery training. Secondly, investigate technologies to avoid airplane upsets, or to facilitate recovery, if one encountered. Flight envelope protection systems can help keep the aircraft from going outside the envelope, but currently there are only two manufacturers that have employed this technology. As far as assisting the pilot to recover, technologies can be employed here, too. For example, Ground Proximity Warning Systems, Traffic Collision Avoidance Systems, and Windshear escape systems have been designed to provide pilots with escape guidance information. Perhaps this concept could be employed to help pilots determine how best to recover from upsets, i.e., follow the flight director guidance for the optimum recovery escape maneuver. Other ideas may include g awareness systems. Test pilot airplane upset recovery performance with soft disconnect autopilots.

8. Change the FAA Pilot Training Standards (FAA-S-8081-5C, FAA-S-8081-12A, and FAA-S-8081-14) to better prepare pilots for airplane-upset recovery in air transport aircraft. Mandate airplane upset recovery training.

9. Develop an industry wide strategy for providing the most effective training to the pilot at each point in his or her career. This should consider exposing pilots to repeated training on a specific scenario rather than training on all scenarios during a single simulator session. Investigate the decay of skills over time and incorporate this effect into training. Define performance criteria for airplane upset recovery that can be incorporated into AQP. Identify what pilots do right in airplane-upset recoveries based on airplane incident data.

10. Incorporate airplane upset recovery training into the Automated Systems Approach to Training and Flight Operations Quality Assurance Programs.

At the Airplane Upset Recovery Training Evaluation Results Review Workshop, it was suggested that the results of this study be incorporated as one element of the Spec401 Project being developed by the ATA Operations Council. The <u>original</u> Spec401 Project referred to during our Workshop, was designed to:

1. Define the knowledge and capabilities that US air carriers seek in new-hire pilots, expressed as course objectives and learning outcomes,

2. Distribute that information to colleges, flight training centers and students hoping to become professional pilots, and then

3. Assess novice pilots who seek employment in the industry on that knowledge and those capabilities using an industry-developed and administered examination.

As originally designed, the Spec401 Project would have provided an ideal vehicle for introducing the results of our Upset Recovery Training Evaluation to collegiate aviation and incorporating the material in their curricula. Unfortunately, the current corporate and economic distress being experienced across the air transport industry has caused the ATA Operations Council to scale back the Spec401 Project for the present time. In its current format, the Project may be too restricted to serve our needs effectively. However, it is possible that the Operations Council might be willing to use the findings of our Upset Recovery Training Evaluation as a "demonstration module" for the original Spec401 concept. This prospect should be immediately explored and, if all parties are agreeable, the development of the demonstration module described above should be promptly initiated.

6. DISCUSSION

The major issues revealed by this airplane upset training evaluation were: 1) the variability in new hire pilots, 2) the importance of both knowledge and proficiency, 3) potential negative effects of aerobatic flight, 4) the difference between stall recovery and pre-stall recovery procedures, 5) the use of secondary controls in airplane upset recovery, 7) the use of bank to unload the airplane during an upset, 8) airplane upsets in which aggressive controls are not appropriate, 9) the challenges of developing a quantitative measure of pilot recovery performance, 10) the effect of stress, 11) mass versus distributed practice, and 12) common errors. Each of these issues is described in the following sections.

6.1 VARIABILITY IN NEW HIRE PILOTS

One of the most striking findings was the very large variability in evaluation pilots in both background and performance. These variabilities support a recommendation by Smallwood (2000) to "adapt training appropriately to the needs of pilots flying modern aircraft" (p. 2).

6.1.1 Variability in Evaluation Pilot Background

As for variability in background, although all evaluation pilots were in their probationary year with air carriers, there were considerable differences in the number of flight hours they had flown with hours ranging from 943 to 12,347. Evaluation pilots also varied in the amount of flight training they had received and whether or not they were instructors themselves. This reflects trends in the flightcrew market. As stated by Learmount (1998) there is "Increasing demand versus dwindling supply (with a drop in

the numbers of the formally selected and trained ex-military pilots); a reducing airline commitment to training; and increasing pilot career self-management." (p. 38). Human factors in commuter airplane crashes include poor handling of emergencies, improper instrument flying procedures, and fuel mismanagement.[173]

6.1.2 Variability in Evaluation Pilot Performance

Regarding the variability in performance, work by Wiggins (1997) may shed some light. He proposed that differences between experts and novices would be most pronounced in unfamiliar situations. His theory is presented in Figure 38. The evaluation pilots in the current study would have fallen into both the inexperienced and intermediate operator performance categories. Seven of the eight evaluation scenarios were unfamiliar to them. Only the Charlotte windshear scenario was familiar. The most unfamiliar, Shemya, was the airplane upset scenario from which the fewest evaluation pilots recovered. This combination of experience level and type of situation may have resulted in the variability in performance that was evident in this study.

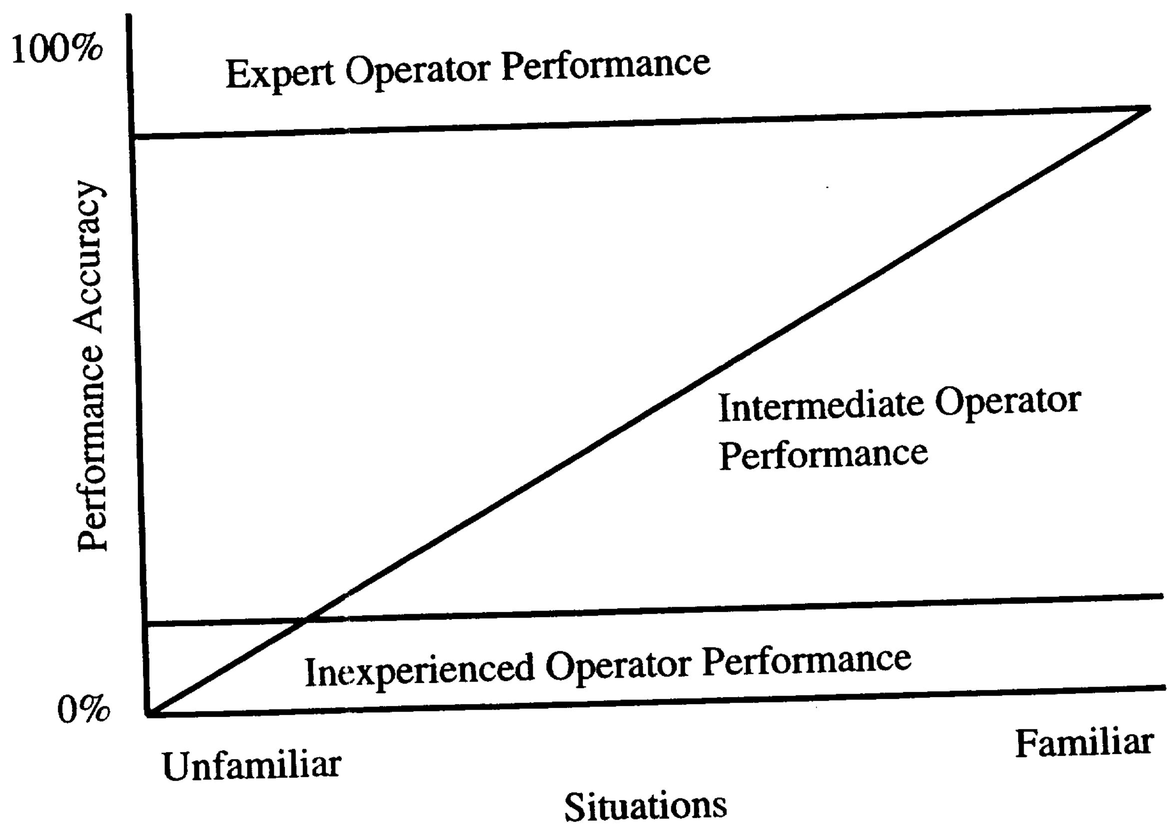

Figure 38. Operator Performance as a Function of Experience (Wiggins, 1997, p. 63)

[173] Baker, S.P., Lamb, M.W., Li, G., and Dodd, R.S.: "Human Factors in Crashes of Commuter Airplanes" Aviation, Space, and Environmental Medicine, 1993, 64, 63 – 68.

There was clearly a very large amount of variation in performance – even between evaluation pilots in the same group. For some variables, the standard deviation was as large as the mean. This variability reduced the statistical power of the study from an expected 0.90 beta to 0.74 beta. Variability in performance of commercial pilots is not new. In a study of 33 commercial pilots in 1971, 39% had below average scores on an in-flight check ride.[174] Both the variability in flight hours and in performance, however, reflects the variability in the current airline pilot population – variability that is only increasing as flight hour requirements are decreasing as the demand for pilots is increasing. As such, similar results may be expected for larger pilot populations.

The relationship between flight time and performance is not a simple correlation. In recent work, only multiengine and Part 121/135 flight hours were significantly correlated with performance in a ground-based simulator.[175] The subjects were 129 commercial multiengine–rated pilots. Performance on briefing, takeoff, departure, steep turns, holding, area arrival, and precision approach was rated by instructors. There were significant correlations of multiengine time and performance on holding (+0.18), area arrival (+0.21), and approach (+0.25); Part 121/135 time and takeoff (+0.23), enroute (+0.19), area arrival (+0.20), and approach (+0.24). This work has been expanded with an additional 217 pilots. These data indicate that both multi-engine and recent flight time are significantly correlated with performance in a ground simulator.[176] Recent flight time (i.e., more than 400 hours per year versus 101 to 400 hours per year) decreases the risk of accident by over 300%.[177] The data were from aircraft accidents that occurred between 1982 and 1988. The trend for increased accident risk as flight experience decreases has also been reported for naval aviators.[178]

There were also differences in the airplane-upset training that evaluation pilots received. American Airlines had the most extensive lecture (8 hours) while other airlines had much less (e.g., one hour). All ground simulator training was similar, but mostly reflected recovery from unusual attitudes and not the upset phase itself.

In spite of the variability in flight experience and training, it was not surprising to find that evaluation pilots rated their confidence in the mid to high range. Pilots were not rating their ability to recover. Instead they are rating their confidence in themselves and their skills. Confidence is a positive measure of being a commander and pilots by definition are in command of their aircraft. To assess whether confidence was related to

[174] Seltzer, L.Z., and McBrayer, J.D.: "A Study of the Errfect of Time on the Instrument Skill of Private and Commercial Pilot," (FAA-DS-70-12). Cahokia, IL: Parks College of Aeronautical Technology of the Saint Louis University, March 1971.
[175] Bramble, W.J. and Koonce, J.M. The path ro airline employment: Flight experience and performance in a full-mission flight simulation. Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting, 1998, 797 –800.
[176] Mayes, D.K., Bramble, W.J., and Koonce, J.M.: "Flight Experience for Becoming a Professional Pilot: Does It Really Matter?," Proceedings of the Tenth International Symposium on Aviation Psychology, 1999, 577- 580.
[177] Guide, P.C. and Gibson, R.S.: "An Analytical Study of the Effect of Age and Experience on Flight Safety," Proceedings of the Human Factors Society 35th Annual Meeting, 1991, 180 – 184.
[178] Borowsky, M.S.: "Rewadiness and Retention: Pilot Flight Experience and Aircraft Mishaps," Norfolk, VA: Navcal Safety Center, 24 June 1986.

performance, a Pearson Product Moment Correlation was calculated between the evaluation pilot's confidence rating and the total number of scenarios from which he or she recovered. The correlation was significant (+0.30); the confidence rating increased as the number of scenarios recovered increased.

6.2 KNOWLEDGE AND PROFICIENCY

A number of airline training experts have noted a trend in increased pilot error. One of these, Smallwood (2000) summarized this trend, "Over the past five years, a big rise has been recorded in crew errors, resulting, either from insufficient pilot knowledge of aircraft systems and procedures, or pilot proficiency failure." The distinction between knowledge and proficiency is an important one. In this study, three of the groups (i.e., those with airplane upset training or the in-flight simulation training) had the knowledge to recover but not all had the proficiency. This was especially clear from the failure to consistently disconnect the autopilot at the onset of an airplane-upset scenario.

The autopilot, as implemented in the Learjet, was a means to input control surface or simulated trim commands into the aircraft without these inputs being reflected onto the evaluation pilots control wheel (and, thus, appeared as uncommanded aircraft responses). The autopilot required a positive "button push" to disengage (note the evaluation pilot did not have to hold the autopilot disconnect button). This feature is comparable to most transport category aircraft but does not allow the "control-stick-steering" (or overpowering the autopilot by applying a certain force level on the controls) that is available in those aircraft. In the Learjet, the wheel-column could be forced to move with the autopilot connected, but this pilot input would not be applied to the control surfaces.

The requirement to disconnect the autopilot whenever uncommanded aircraft motion occur or whenever one pilot takes control from the other in an emergency, is a logical and agreed upon action and is briefed thusly (in slightly different words), in all of the upset recovery training programs the evaluation pilots were exposed to prior to this airplane upset training evaluation. While the placement of the autopilot disengage button is common between all types of transport aircraft, it is not identical. As a result of the extensive preflight briefings and past habits, this was not thought to be a factor in this evaluation. Emphasis was made in all of the preflight briefs to point out the autopilot disengage button (as well as the control trim button and other features of the wheel-column) and it was made clear that in any event that called for disengaging the autopilot, that specific button should be pressed.

The distinction between knowledge and proficiency has been expanded in a model of the competent and expert pilot (see Table 78). In this study, the evaluation pilots were competent and had some but not all the components of an expert pilot. Two of the groups did not have the knowledge of airplane upset recovery techniques. All five groups showed problems in skill and ability. Because all the evaluation pilots were volunteers, all showed the expert pilot component of working continuously to improve knowledge, skill, and abilities. All were also highly motivated. This suggests that performance of this group of pilots may have been superior to those who did not volunteer for this study. Further, the surprise scenarios were used to assess the generalizability of the data from the eight evaluation scenarios to the real world. In the

surprise scenarios, evaluation pilots typically took longer to make control inputs than during the eight evaluation scenarios (e.g., Birmingham). This suggests that the expected performance of pilots in recovering from airplane upsets encountered while flying the line may be worse than in training/testing situations in which they expect an upset attitude encounter.

Table 78. Model of the Competent an Expert Pilot[179]

	Competent Pilot	Expert Pilot
Knowledge	Knows the domain sufficiently to pass FAA exams	Knows the domain Knows him/herself Knows the environment Knows the organization
Skills or Abilities	Skills and abilities sufficient to pass FAA exams	Highest technical skill Superior mental abilities for problem diagnosis, risk assessment, and problem resolution Ability to focus attention Ability to change focus of attention Adaptable communication skills
Behavior	Usually follows FARs Takes the VFR and IFR proficiency tests	Avoids situation that push skill Keen observer of the flight environment Establishes baseline for normal operations Makes contingency plans Works continuously to improve knowledge, skill, and abilities
Motivation	May be primarily focused on matters outside of cockpit	To continuously learn about domain To be skeptical about "normal" situation To overcome pressures to push risk To change focus of attention when needed

Finally, the results of this study match a summary of industry studies which show that an area of difficulty is "maintenance of skills required in local asymmetric training in both simulator and aircraft" (Smallwood, 2000, p. 12).

6.3 AEROBATIC FLIGHT

Perhaps a measure of not being "over confident", there was a universal desire for more training, especially airplane upset training. Evaluation pilots also rated the in-flight training as the best for airplane upset recovery. Comments during the debriefing also indicated that aerobatics were not perceived as useful as was thought prior to the evaluation flight. This supports some opinions that aerobatics in an aircraft that does not closely duplicate the environment and responses of a transport category aircraft does little

[179] Kochan, Jensen, Chubb, and Hunter, 1997, p. 21

more than reduce some of the fear of unusual attitudes. It may even reinforce false perceptions of control effectiveness and the importance of correct sequencing of control inputs. Nor did aerobatic flight have a significant effect on airplane upset recovery. This possible effect of aerobatic training in small, maneuverable aircraft should be tested directly given the use of this type of training is proposed at several major airlines.

There are other aspects to aerobatic flight that change a pilot than just the experience of being upside down in an aircraft. The FAA has issued an advisory circular on the physiological effects of G forces. AC 91-61 states that "G-tolerance depends on an individual's height, age, elasticity of blood vessels, training, the responses of the heart and blood vessels and general health."[180] This issue must also be addressed if aerobatic flight is included in airplane-upset training.

6.4 STALL RECOVERY

One of the results of this study is the response to icing induced stall where the aircraft would exhibit classic stall behavior without a buildup stall warning. In these cases it appeared that without stall recovery training (that in reality is stall warning training, e.g., response to a stall horn or stick shaker) controls would be applied unsuccessfully since those techniques provide recovery from an unstalled condition whereas recovery from a complete stall requires a different technique. The evaluation pilots associated an aerodynamic stall with the behavior that was learned to respond to a prestall condition. The evaluation pilots would correctly identify a stall due to buffeting and wing drop. They equated this with prestall recovery response to a stall horn or stick shaker. This is prestall. The recovery to prestall is add power and pull nose up so as not to lose altitude – powering out of the prestall condition. The correct recovery from a true stall is to reduce angle of attack and this necessitates pushing the yoke forward which will probably cause altitude loss.

An expert in the field stated "The issue of "stall/post stall" recovery training has been a VERY contentious issue ... we came to an agreement that such recovery training in simulators is seeking behavior modification in the trainees, and not teaching precision flight path control or accurate aircraft handling qualities in those areas at/beyond the stall where the simulator math model may not be based on precisely validated flight test data. The issue of training stall/post stall recovery in simulators in the air carrier industry will continue, I believe, to be as controversial as abortion and gun control." (personal communication April 13, 2001).

Recovery from icing induced stalls (such as the Roselawn and Detroit scenarios) suffered from two apparent flaws. The first was the tendency to treat this stall in the same way as the "approach to stall" exercise is performed in ground simulations and check rides - add power; fly out of it; and don't loose altitude (or you fail your check ride). This recovery technique works (for the most part) when it is initiated at the first sign of a stall, which in most transport aircraft is a stick shaker. In this case the aircraft is not really stalled and may be as much as 1.1 or 1.2 x Vstall (depending on the

[180] The Weekly of Business Aviation NTSB Warns Against Aerobatic Flight For Pilots With Cardiac Conditions. January 18, 1999; Pg 30; Vol. 68, No. 3.

implementation of the stick shaker logic in each specific aircraft). Applying power and flying out are perfectly valid options and, unless the situation is exacerbated by turbulence, will probably be successful.

The difference between recoveries from approach to stall and stall have been noted elsewhere.[181] "Most pilots are trained in recovering from an approach to stall. That is, once the buffet begins, or the stick-shaker fires, they are taught to recover by adding all the power possible, and keeping the nose of the aircraft up to minimize altitude loss. A similar technique is used for flying through wind-shear encounters. The technique is absolutely appropriate to an approach-to-stall recovery. However, in an upset, it is possible to encounter an accelerated stall, a condition not nearly as familiar to most pilots, especially those who do not have a military background or aerobatic training."

When an aerodynamic stall occurs, either by exceeding the wing angle of attack or, in the case of ice buildup, causing part or all of the wing or tail to experience a drastic loss of lift, even if the wing angle of attack is below stall - the aircraft's angle of attack must be reduced further so as to exit the stall condition. In this case applying power and flying out without loss of altitude probably will not work. In many icing cases the stall will occur without the usual warning (i.e., stick shaker or angle of attack indication) and may be abrupt and quite asymmetric. Treating a stall due to icing the same as a stall warning recovery is not correct and should be emphasized in initial and recurrent training.

The second flaw is the pilots' inherent desire to not loose altitude, or not to descend below the assigned altitude and to not get closer to the ground. Correctly reducing angle of attack and increasing speed, so as to get away from the conditions that produced the icing stall, will result in a loss of altitude. This fact must be accepted by the pilots and the realization that the primary concern of gaining or retaining aircraft control may require using the altitude below the aircraft to the fullest extent.

Correct knowledge and recurrent training in these procedures should reduce these common mistakes. Mistakes also noted by Smallwood (2000) who identified "Acquisition and maintenance of instrument flying skills" as an area of difficulty in current airline training.

6.5 USE OF SECONDARY CONTROLS

From accident data Lykins (1997) concluded, "the voice recorder on some flights told us that the unusual attitude problem was recognized but the flight data record and the wreckage pattern told us that the wrong recovery technique was employed" (p. 1). One of the techniques typically not tried in these accidents was the use of secondary controls. Lykins recommended "A discussion of primary and secondary controls for recovery use should be part of the ground school including when and how the secondary controls

[181] Bradley, P. Upset Recovery Training: In- aircraft training is becoming more common as pilots attempt to prepare themselves to handle the unexpected. Business & Commercial Aviation November 1998; p. 87; Vol. 83, No. 5.

might be employed. This might include spoilers/speed brakes/flaps/asymmetrical thrust, or a combination of these controls" (p.3).

Further, it is also not surprising that there were significant differences in the perceived difficulty of the evaluation scenarios. Evaluation pilots rated Charlotte as easiest and all but one evaluation pilot recovered from this windshear scenario. Pittsburgh was rated as the most difficult. Simply put, the Charlotte windshear scenario was one that was not only well understood, discussed and practiced, it required only a primary control recovery. The Pittsburgh scenario, on the other hand, not only was more startling but also required non-intuitive and non-learned pilot inputs to expedite a recovery.

6.6 USE OF BANK

For nose high scenarios the most common mistake among evaluation pilots was not using bank angle to change the direction of the lift vector to recover from the initial pitch upset. While apparently included in current airplane upset training curriculum the inability to apply this response indicates either a lack of understanding or recognition. This again suggests the importance of knowledge and proficiency.

6.7 PILOT FLYING EXCESSIVE BANK

In a summary of airline industry studies on the increase in the number of crew errors, Smallwood (2000) stated that one of the areas of difficulty was "Acquisition of high standards of flight management skills, both in first officer and command areas" (p. 12). This was evidenced by the problems in recovery from the Toledo evaluation scenario in which the pilot not flying did not take control of the aircraft soon enough in excessive bank. Part of problem may be due to the lack of specific criteria for the pilot not flying to take over due to excessive bank angle (or exceeding other flight conditions).

6.8 AGGRESSIVE CONTROL INPUTS NOT ALWAYS RIGHT

Not all airplane-upset recoveries require aggressive control inputs. Some like with high-altitude flight characteristics, require just the opposite. Both types of recovery techniques and the flight conditions as to when to apply each should be emphasized.

6.9 DEVELOPING A QUANTITATIVE MEASURE OF PILOT RECOVERY

The quest for an automated, quantitative measure of pilot performance has been long, hard, and fraught with failure. An area of repeated failure has been in predicting flight performance from simulator performance especially for emergency procedures. This is demonstrated in an early study for the Navy in which researchers found that "there was not a very direct correspondence between the exercises conducted in the simulator (performance of emergency procedures during flight either when flying straight and level within a context of a simulator navigational flight, and the flying of a precision descent) and the exercises observed in actual flight" (Bowen, Bishop, Promisel, and Robins, 1966, p. 52). Although simulator technology has improved the ability to predict flight performance from simulator performance has not (Gawron and Reynolds, 1995). There have been improvements in pilot performance measurement with the addition of eye scan data. In a study to find measures to discriminate among student pilots, low time (200 to 1000 hours) instructor pilots, and high-time instructor pilots (> 1000 hours),

performance measures combined with eye scan gave the highest classification accuracies. Measures included root mean squared error for airspeed, altitude, and heading, root mean squared roll and pitch velocity, and percent of time in altitude (+/- 50 feet), airspeed (+/- 10 knots), and heading (+/- 5 degrees).[182]

Other researchers have demonstrated that where pilots receive their training affects their performance. Trained observers rated the simulator performance of pilots trained in a university setting better than those trained in less formal setting under Part 61. The subjects were 90 pilots, ten were students, 80 were from the general aviation community.[183]

Although there were significant differences in ratings, there were very few significant differences in performance variables among the five training groups (see Table 79). Maintaining airspeed above stall is a technique critical to airplane recovery. From the Birmingham scenario data, it is not surprising that the evaluation pilots who did use the technique were in the Aero/Upset and In-flight training groups since this technique seems to require both academic training and in-flight experience. There was a significant difference in the Shemya time to stick shaker: the No Aero/No Upset group was significantly slower (6.775 seconds) than the Aero/Upset group (4.408 seconds). For Nagoya the Aero/No Upset group had a lower minimum airspeed (122 KIAS) but greater change in airspeed (34 KIAS) across the evaluation scenario than the In-flight group did (142 and 14 KIAS, respectively). For Charlotte, the Aero/No Upset group was significantly faster (75 msec) than the No Aero/Upset group (3.4 seconds) in putting the correct elevator input. One of the most surprising results was the lack of a significant difference in groups who received airplane-upset training and those who did not in time to announce the problem or disconnect the autopilot. They all did not complete these steps.

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[182] Kramer, A., Tham, M., Konrad, C., Wickens, C., Lintern, G., Marsh, R., Fox, J., and Merwin, D.: "Instrument Eye Scan and Pilot Expertise," Proceedings of the Humaqn Factors and Ergonomics Society 38th Annual Meeting, 1994, 36 – 40.

[183] Tagliaferri, K., Tigner, R.B., Wollard, J., and Jensen, R.: "Simulator and Flight Test of General Aviation Piloting Skill,". Proceedings of the Ninth International Symposium on Aviation Psychology, 1997, 751 – 754.

Table 79. Summary of Performance Differences in the Evaluation Scenarios as a Function of Training Group[184]

Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
Announce problem. Time to announce problem	Announce problem. Time to announce problem	Announce problem Time to announce problem	Announce problem. Time to announce problem	Announce problem. Time to announce problem	Announce problem. Time to announce problem.	Announce problem. Time to announce problem	Announce problem Time to announce problem
Initially requires full aileron input to fight uncommanded roll. Time to correct aileron input Time to correct rudder input	Crosscheck instruments.	Depress master disconnect button. Time to disconnect autopilot Time to correct aileron input	Depress master disconnect button. Time to master disconnect	Maximum thrust. Time to definitive thrust change	Attitude crosscheck.	Use full opposite aileron, rudder, and possibly split thrust to roll to wings level. Time to correct aileron input Time to correct rudder input Time to correct throttle input	Angle of attack should be reduced: Time to correct aileron input Time to correct rudder input Time to correct throttle input Time to correct throttle split
Full down elevator with trim to keep the AOA within limits. Time to correct elevator input Time to trim input	Disconnect autopilot. Time to master disconnect	Recognize PIO tendency.	Use full nose down column. Time to correct elevator input Wheel full forward	Disconnect autopilot. Time to autopilot disconnect	Disconnect (Autopilot, etc., etc.). Time to master disconnect	Angle of attack should be reduced: Time to correct elevator input Time to correct (split) throttle input	Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed. Time to correct elevator input Max airspeed
Use bank angle as required to control flight path. Adjust phi to control gamma	Aggressively roll right to approximately wings level. Time to correct aileron input	Back out of pitch control loop to avoid coupling. Time to correct elevator input	Roll the aircraft to reduce the vertical component of the lift vector and prevent the aircraft from climbing too steeply. Actively adjust bank angle to control flight path angle. Time to correct aileron input	Leave gear and flaps unchanged. Flaps/gear changed	Attempt to use opposite rudder and aileron. Time to first correct rudder input Time to first correct aileron input	Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed. Max airspeed	Flaps may be set to 20°, speed permitting. Time to set flaps back to 20 degrees
Airspeed should maintain safe margin above accelerated stall speed. Airspeed > stall	Use rudder to enhance roll rate. Time to correct rudder input	Use low pitch control gains. Low pitch gain [redacted]	Airspeed should be kept low to reduce the gs and the consequent bank angle required to maintain level flightpath. Airspeed at emergency [redacted]	Rotate to 15° pitch attitude. [redacted] Time to attain 15 degrees	Unload pitch axis – push, don't pull. Time to first correct elevator input Phi at first correct elevator input	Flaps should be set back to 20°. Time to set flaps back to 20 degrees	Return to starting altitude/heading. Altitude lost

[184] Shading indicates significant difference.

Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
			[redacted]	theta	elevator input		
	Retard power to remain near corner speed. Time to correct throttle input Delta from 210 KIAS corner speed	Use low frequency pitch inputs. Max Nz	Call for emergency nose down trim. Time to call emergency trim input	Accept low airspeed. Accept low airspeed	"Unload" pitch if more roll rate is required or if bank will exceed 70-90 degrees. FES input at phi = 70 degrees	Return to starting altitude/heading. Altitude lost	Inform ATC. Time to inform ATC of altitude deviation
	Full aft column and nose-up trim to 2.5 g pull up. Time to correct elevator input Time to trim input Maximum normal acceleration	Use lead compensation in pitch. Min Nz	Investigate source of problem.	Use near stick shaker angle of attack. Time to first stick shaker activation	Use split thrust to roll to wings level. Time to throttle split	Inform ATC. Time to inform ATC of altitude/heading change	Troubleshoot deice system. Time to troubleshoot deice system
	Maintain climb until 1500 AGL. Altitude lost	Don't chase altitude. Chase altitude	Cautiously release master disconnect button. Call to investigate source of problem	Do not lower nose in an attempt to increase airspeed. Lower nose for airspeed Time to reach 500 ft/min Altitude lost	Total thrust should be adjusted in consideration of both crossover speed and corner speed. Thrust delta Airspeed delta	Troubleshoot deice system. Time to troubleshoot deice system	
		Trim to near 1 g flight. Time to correct trim input	Inform ATC of problem/altitude deviation/inability to hold heading. Time to inform ATC of inability to hold altitude or heading		Return to starting altitude/heading Heading change.		

Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
		Investigate source of problem.			Inform ATC. Time to inform ATC of altitude and/or heading change		
		Cautiously release master disconnect button. Time to master disconnect			Troubleshoot rudder hardover. Time to troubleshoot rudder hardover		
		Inform ATC of problem/altitude deviation. Descend to lower altitude.					

There were significant scenario differences as expected in time to first correct rudder input (Birmingham fastest, Toledo slowest), correct aileron input (Birmingham fastest and Toledo slowest), and elevator input (Nagoya fastest and Toledo slowest). There was also a significant difference in percent correct recovery actions (Roselawn lowest and Toledo highest) and number of correct pitch inputs (Charlotte lowest and Birmingham, Toledo, Shemya, Nagoya, and Detroit highest), correct roll inputs (Roselawn lowest and Birmingham, Toledo, Shemya, Pittsburgh, and Detroit highest), and correct throttle inputs (Birmingham, Shemya, Nagoya, and Charlotte lowest and Toledo highest). These differences reflect the diversity in the evaluation scenarios that were selected to cover the complete range of types of airplane upsets, aircraft, and phase of flight (see Table 20).

One puzzling result of this study was the lack of ability of the time and sequence measures to identify differences in training among pilots with no military background while these measures have been used repeatedly with success among military pilots. Additional research should be conducted with experienced pilots who have been trained in airplane upset recovery as well as instructor pilots to refine the measurement and analysis of pilot performance in airplane upset recovery since performance of pilots who recovered versus those who did not was not always significantly different in timing and sequence as was originally hypothesized and has been shown to discriminate among military pilots. For civilian pilots, measures of amplitude of input may also be needed as well as other nuances such as duration of input and tolerance to misapplied controls.

6.10 THE EFFECT OF STRESS

The many instances where the evaluation pilot did not disengage the autopilot (or disconnect the automation - as it is referred to in many airplane upset recovery training programs) seem to indicate that thought processes that were learned and (most likely) applied in previous training were skipped or forgotten when actual, realistic scenarios were encountered (as during the evaluation flights). The often noted symptom of "freezing on the controls" or "waiting" for the control input to have the requested effect before going on to the next step would appear to inhibit further action on the part of the pilot. However this phenomena has not be tested in ground simulators and may broader than just in flight.

It is our opinion that the unexpected realism and suddenness of some of the scenarios may have caused such a response (or lack thereof). If, indeed, this is the case, further thought should be given to creating methods that better prepare pilots to not only recognize upsets and relate the correct recovery procedure but also to continue to think and perform while under this type of stress.

The unexpected realism and suddenness of some of the scenarios may have caused such a response (or lack thereof). If, indeed, this is the case, further thought should be given to creating methods that better prepare pilots to not only recognize upsets and relate the correct recovery procedure but also to continue to think and perform while under this type of stress. There is also a tendency for “Many pilots, even highly experienced ones, [to] tend to pull back on the control column when confronted with a

sudden upset. Whether it is an innate response to fear, or a desire to get the nose of the aircraft away from the ground, pulling in an upset can have dire consequences."[185]

Further in comparing performance of evaluation pilots who recovered from the evaluation pilots who did not, confusion was prevalent for the evaluation pilots who did not recover. This was evidenced by rapid switches between power settings, inadvertent activation of controls, failure to use trim or roll during pitch up, and occurrences of roll oscillations. While confusion in the cockpit in emergency situations is not unusual, the degree of confusion noted by the safety pilots was much more indicative of real-world scenarios than that noted during ground-based upset recovery training.

6.11 MASSED VERSUS DISTRIBUTED PRACTICE

Of concern in this training scenario was the effectiveness of "one session" training. How well do participants encode and consolidate knowledge and develop skill in a single session? Most of the relevant research is still in the universities (Arizona State,[186] Carnegie Mellon,[187] Oregon State,[188] Saint John's,[189] San Jose State,[190] Simon Fraser,[191] Texas Christian,[192] University of New England,[193] University of Sidney,[194,195] Washington University[196]). The few studies that are not, are related to knowledge rather than skills.[197,198] This study was the first to evaluate the effectiveness of one-trial learning in flight training. It appears in this study, the inability to identify or characterize the airplane upset hampered the application of a learned recovery technique. This inability

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[185] Bradley, P. Upset Recovery Training: In- aircraft training is becoming more common as pilots attempt to prepare themselves to handle the unexpected. Business & Commercial Aviation November 1998; p. 87; Vol. 83, No. 5.
[186] Damos, D. Effect of the amount of single task practice on the performance of discrete task combinations. Tempe, AZ: Arizona State University, September 1986.
[187] VanLehn, K.A. Learning events in the acquisition of three skills. Pittsburgh, PA: Department of Psychology Carnegie Mellon University, December 1990.
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[191] Randall, W.E., Dickinson, J., and Goodman, D. Studies in one-trial motor learning. Journal of Human Movement Studies, 1995, 29(5), 229-249.
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[193] Biggs, J.B. and Bowlay, D.J. Informational input and one trial learning. Australian Psychologist, 1966, 1(1), 83.
[194] Wenderoth, P.M. A note on the replication of Rock's one trial learning experiment. Psychonomic Science, 1970, 19(6), 371.
[195] Crawford, J. Hunt, E., and Peak, G. One trial learning of disjunctive concepts. Journal of Verbal Learning and Verbal Behavior, 1967, 6(2), 207-212.
[196] Pizzuro, S.A. and van Laer, J. One-trial learning with control of item difficulty. Seattle, WA: Washington University, July 1967.
[197] Anderson, R. J. one-trial learning and quantum psychophysics: A synthesis. Washington, NY: Naval Training Device Center, June 1964.
[198] Martin, M.A. and Stewart, R.A. Repetition and one trial learning. Australian Journal of Psychology, 1969, 21(1), 65-68.

was due to the differences in aircraft state and environmental conditions as well as pilot state. More practice is needed – demonstrating a specific control malfunction or icing. For windshear the response was not so much to the external conditions but to the conditioning to the word "windshear". In this scenario windshear was highly probable due to the weather conditions and pilots had practiced windshear recovery in the simulator. In the simulator there is often no understanding required, only execution of a response. In this study, pilots tried to understand the phenomena but were without the tools to do so – so they did nothing or continued to do what they were doing (very much like the real accident scenarios).

Smallwood (2000) also suggested that "more may be learned in three spaced learning periods of 30 minutes each than in one period of 90 minutes" (p. 100). This advantage of distributed rather than massed training may explain the lack of an effect of the in-flight simulation training on airplane-upset recovery.

6.12 COMMON ERRORS AND SAFETY PILOT OBSERVATIONS

In many of the evaluation scenarios (e.g., Birmingham), the most common mistake among evaluation pilots was not using bank angle to change the direction of the lift vector to recover from the initial pitch upset. It was also clear that training for recovering from Birmingham should include a rule that if the pilot not flying observes a bank angle that exceeds an aircraft specific value, he or she should take control.

For Shemya, the most common error made by evaluation pilots who did not recover this scenario was not turning off the autopilot prior to making a large control input. In addition, those who did recover were also very light on the control inputs since they were having to deal with a very large pitch transient coupled with undesirable flying qualities. In this scenario correct recovery procedures call for "recognizing the problem (and understanding that large inputs are undesirable) and backing out of the control loop" – much different than any of the other scenarios.

The scenario with by far the best recovery performance was Charlotte. For that scenario all but one of the evaluation pilots recovered. During the debrief the reason became obvious – all evaluation pilots had received extensive windshear training. The training included videos, academic discussion, and most importantly repetitive exercises in a ground simulator. Universally all evaluation pilots performed the windshear exercises until they were able to recover 100% of the time. These exercises were repeated whenever the evaluation pilots were in the simulator.

For several scenarios (e.g., Toledo), the evaluation pilots who recovered were quicker (~2.2 seconds), pulled less g (~1 less), and lost less altitude (~1000 feet less). Evaluation pilots who recovered also had lower pitch gains when needed, e.g., Shemya. They also used alternate controls more quickly (e.g., emergency trim for Nagoya, thrust for Pittsburgh, and airspeed for Roselawn and Detroit) (see Table 80).

Table 80. Summary of Performance Differences in the Evaluation Scenarios as a Recovery/No Recovery Group[199]

Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
4	30	4	12	34	8	15	16
Announce problem. Time to announce problem	Announce problem. Time to announce problem	Announce problem Time to announce problem	Announce problem. Time to announce problem	Announce problem. Time to announce problem	Announce problem. Time to announce problem.	Announce problem. Time to announce problem	Announce problem Time to announce problem
Initially requires full aileron input to fight uncommanded roll. Time to correct aileron input Time to correct rudder input	Crosscheck instruments.	Depress master disconnect button Time to disconnect autopilot Time to correct aileron input	Depress master disconnect button. Time to master disconnect	Maximum thrust. Time to definitive thrust change	Attitude crosscheck.	Use full opposite aileron, rudder, and possibly split thrust to roll to wings level. Time to correct aileron input Time to correct rudder input Time to correct throttle input	Angle of attack should be reduced: Time to correct aileron input Time to correct rudder input Time to correct throttle input Time to correct throttle split
Full down elevator with trim to keep the AOA within limits. Time to correct elevator input Time to trim input	Disconnect autopilot. Time to master disconnect	Recognize PIO tendency.	Use full nose down column. Time to correct elevator input Wheel full forward	Disconnect autopilot. Time to autopilot disconnect	Disconnect (Autopilot, etc., etc.). Time to master disconnect	Angle of attack should be reduced: Time to correct elevator input Time to correct (split) throttle input	Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed. Time to correct elevator input [illegible]
Use bank angle as required to control flight path. Adjust phi to control gamma	Aggressively roll right to approximately wings level. Time to correct aileron input	Back out of pitch control loop to avoid coupling. Time to correct elevator input	Roll the aircraft to reduce the vertical component of the lift vector and prevent the aircraft from climbing too steeply. Actively adjust bank angle to control flight path angle. Time to correct aileron input	Leave gear and flaps unchanged. Flaps/gear changed	Attempt to use opposite rudder and aileron. Time to first correct rudder input Time to first correct aileron input	Airspeed should be increased as required to allow pulling without roll off but not excessively above corner speed. Max airspeed	Flaps may be set to 20°, speed permitting. Time to set flaps back to 20 degrees
Airspeed should maintain safe margin above accelerated stall speed. Airspeed > stall	Use rudder to enhance roll rate. Time to correct rudder input	Use low pitch control gains. [illegible] Time to stick shaker	Airspeed should be kept low to reduce the gs and the consequent bank angle required to maintain level flightpath. Airspeed at emergency	Rotate to 15° pitch attitude. Time to correct elevator input Time to attain 15 degrees theta	Unload pitch axis – push, don't pull. Time to first correct elevator input Phi at first correct elevator input	Flaps should be set back to 20°. Time to set flaps back to 20 degrees	Return to starting altitude/heading. Altitude lost

[199] Shading indicates significant difference.

Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
			Minimum airspeed Airspeed delta				
	Retard power to remain near corner speed. [redacted] Delta from 210 KIAS corner speed	Use low frequency pitch inputs. Max Nz	Call for emergency nose down trim. [redacted]	Accept low airspeed. Accept low airspeed	"Unload" pitch if more roll rate is required or if bank will exceed 70-90 degrees. FES input at phi = 70 degrees	Return to starting altitude/heading. Altitude lost	Inform ATC. Time to inforn ATC of altitud deviation
	Full aft column and nose-up trim to 2.5 g pull up. [redacted] Time to trim input [redacted]	Use lead compensation in pitch. Min Nz	Investigate source of problem.	Use near stick shaker angle of attack. Time to first stick shaker activation	Use split thrust to roll to wings level. Time to throttle split	Inform ATC. Time to inform ATC of altitude/heading change	Troubleshoot deice system. Time troubleshoot deice system
	Maintain climb until 1500 AGL. [redacted]	Don't chase altitude. Chase altitude	Cautiously release master disconnect button. Call to investigate source of problem	Do not lower nose in an attempt to increase airspeed. Lower nose for airspeed Time to reach 500 ft/min Altitude lost	Total thrust should be adjusted in consideration of both crossover speed and corner speed. [redacted] Airspeed delta	Troubleshoot deice system. Time to troubleshoot deice system	
		Trim to near 1 g flight. Time to correct trim input	Inform ATC of problem/altitude deviation/inability to hold heading. Time to inform ATC of inability to hold altitude or heading		Return to starting altitude/heading Heading change.		
		Investigate source of problem.			Inform ATC. Time to inform ATC of altitude and/or heading change		
		Cautiously release master disconnect button. Time to master			Troubleshoot rudder hardover. Time to troubleshoot rudder hardover		

Birmingham	Toledo	Shemya	Nagoya	Charlotte	Pittsburgh	Roselawn	Detroit
		disconnect			rudder hardover		
		Inform ATC of problem/altitude deviation. Descend to lower altitude.					

7. RECOMMENDATIONS

First, given the very large variability in flight hours and training of pilots in their probationary year (see section 5.1) and the predicted trend that this will continue (see section 6.1.1), airplane upset training should account for different experience levels. In addition, airplane upset recovery training should be given to all new hire pilots.

Second, given that a defined upset (i.e., Charlotte) was recovered by 39 of the 40 pilots (see section 5.3.5.2), indicates that specific airplane upset training practice might prove valuable and should be provided in the ground simulator. Practice for these scenarios should include repetition of recovery techniques until pilots perform within an empirically defined tolerance as is done with Charlotte. Repetitive practice also plays important role in the ability to recognize the phenomena, understand the relationship of the phenomena and the aircraft state, and apply the correct response (see section 6.2).

Third, the hypothesized beneficial effect of aerobatic training in small, maneuverable aircraft should be tested directly, given the use of this type of training is proposed at several major airlines (see section 6.3). This should be compared with the training effectiveness of using a low-performance, side-by-side configured aircraft for aerobatic training. If aerobatic training of either type is affective, research should be conducted to determine where in a pilot's career this training would be most effective.

Fourth, keeping AOA below stall is a critical airplane recovery technique especially in icing scenarios such as Roselawn and Detroit. Stall recovery should be expanded to include recovery from actual stalls and not only deal with approach to stall conditions (see section 6.4). Airframe and simulator manufacturers must provide post stall data/aero packages for training post stall recoveries. In addition, AOA displays should be considered for addition to flight decks to improve crew Situational Awareness and flight safety.

Fifth, the use of secondary controls such as thrust control and trim is required to aid in some airplane-upset recoveries. In Pittsburgh and Nagoya and in both icing scenarios (Roselawn and Detroit), there was a lack of ability to continue past the recognition phase and understand that different control applications were warranted (see section 6.5).

Sixth, for nose high scenarios the most common mistake among evaluation pilots was not using bank angle to change the direction of the lift vector to recover from the

pitch upset. While included in current airplane upset training curricula the inability to apply this response indicates a need for repetitive practice (see sections 6.6 and 6.12).

Seventh, specific criteria for the pilot-not-flying to take over due to excessive bank angle (or exceeding other flight conditions) were not observed (see sections 5.3.2 and 6.7). Airplane upset training should include procedures that address this issue considering both aircraft performance and Crew Resource Management. The procedures should also take into account aircraft flight condition and performance. Finally these criteria should be included in the training manuals for each aircraft.

Eighth, not all airplane-upset recoveries require aggressive control inputs. Some, like high-altitude airplane upsets, require just the opposite. Both types of recovery techniques, and the flight conditions during which to apply each, should be emphasized (see section 5.3.3).

Ninth, additional research should be conducted: 1) to assess line pilot performance with experienced pilots who have been trained in airplane upset recovery. 2) to assess effect of learning through instructing with certified instructor pilots. and 3) to refine the measurement and analysis of pilot performance in airplane upset recovery – since the performance of pilots who recovered versus those who did not was not always significantly different in timing and sequence since these have been shown to discriminate among military pilots performing similar evaluations (see section 6.9). Amplitude measures and more extensive safety pilot evaluation should be investigated as discriminators of airplane upset recovery performance.

8. APPENDIX A -VERIDIAN IN-FLIGHT UPSET RECOVERY TRAINING

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July 1999

CLASSROOM INSTRUCTION

Day 1

- 0 +0 – INTRODUCTION
  - Agenda
    - Introduction
    - Flight Research Group
    - Hanger tour
    - Classroom Instruction
    - Flight instruction
    - Bonanza Flights
    - Learjet flight
      - Ground simulation
  - Classroom Instruction
- MODULE 1 – OVERVIEW
    - Module 2 – Causes of Upsets
    - Module 3 – Aerodynamics
    - Module 4 – Upset Recovery
    - Module 5 – Flight Briefings
  - Flight Instruction
    - Bonanza
      - Flight-path and energy management
      - Basic recovery techniques
    - Learjet
      - Demo
        - Aircraft characteristics
        - Upset recoveries
      - LOFT
        - Selected scenarios
  - Flight Research Group
    - Services
    - Capabilities
    - History
  - In-Flight Simulation
    - Concept
    - Making it work
- 0 + 30 - MODULE 1 - Overview

Problem identified
Evolution of a solution
Training goals
Aircraft Upset
- Definition
- Flight Condition
  - Pitch
  - Bank
  - Airspeed (angle of attack)

Accident Statistics
- Accidents
- Fatalities
- Causes

Evolution of Upset Recovery Training
- Unusual attitude training
- Selected Event training
- Advanced Aircraft Maneuvering Program
- Upset Recovery Training Aid
- Upset Recovery Flight Training

Training Goals
- Improved flying skills
- Upset avoidance strategies
- Enhanced understanding of upsets and recovery techniques
- Greater knowledge of aerodynamics
- Practice in representative aircraft

<u>1 + 0 - MODULE 2</u> - Causes of Upsets

Categories and types
Detailed discussion
Causes of Upsets
- Environmental
- Icing
- Wake turbulence
- System Anomalies
- Control failures
- Pilots
- Inappropriate actions
- Combination

American Eagle Flight 4184
- ATR model 72-212, 31 Oct 94, Roselawn, Indiana
- Probable Cause
  - Super-cooled Large Droplets (SLD)
  - Ice aft of de-icing equipment
  - Aileron "snatch"
    - 60 lbs. control wheel force

Super-cooled Large Droplets

Droplet Size
Certification
SLD Icing
Abnormal accumulation, location, and appearance
Liquid droplets
TAT versus SAT
Be wary when TAT 0°C or warmer while SAT is 0°C or colder
Comair Flight 3272
Embraer EMB-120RT
9 Jan 97, Monroe, MI
Probable Cause
Asymmetric ice accumulation
Airspeed inappropriate for conditions
Wake Turbulence
Accident record
Classification criteria
New research data
B757 Wake Turbulence
Unique Characteristics
Accident scenario
Findings
Wake Avoidance Technique
Reference preceding aircraft
TCAS for separation
Wake Turbulence Separation
Weight Criterion
Reclassification of 57 types
Many business jets
Wake Characteristics
Characteristics
Diameter = wing span
In ground effect
Wake Turbulence Awareness Training
Government - Industry Group
Focus on avoidance

2 + 0 - MODULE 3 - Aerodynamics
Velocity Vector
CG
Attitude
Attitude is the orientation of the aircraft relative to the earth.
Consists of:
Pitch Angle ("Flight Deck angle")
Bank Angle Determines Orientation of Lift
The Velocity Vector
The Velocity Vector (Flight Path)

        - Speed
        - Direction
- Attitude & Velocity Vector
    - Attitude is "where you are pointed"
    - The Velocity Vector (flight path) is "where you are going"
    - The angles between the above two ideas are the "aerodynamic angles"
        - angle of attack
        - angle of sideslip
- Angle of Attack
    - Airplane Angle of Attack
    - Wing Angle of Attack
    - Measured in vertical plane of the aircraft
    - Lift is proportional to angle of attack below stall
- Sideslip
    - Angle between vertical plane and relative wind
    - Sideforce is proportional to sideslip angle below "stall"
- Basic Aircraft Control
    - What is pilot trying to achieve?
        - Control the flight path.
        - Must control the velocity vector.
- How does the pilot control these forces?
    - Lift
        - Magnitude with angle of attack and speed
        - Orientation with bank angle
    - Thrust
        - Magnitude with thrust levers
        - Orientation not usually independently controllable
    - Drag
        - Magnitude with spoilers, gear, flaps, etc.
        - Orientation not independently controllable
    - Gravity
        - Not directly controllable by pilot
- Forces Around a Loop
    - Bending Velocity Vector
    - Normal acceleration bends the velocity vector
- Corner Speed
    - Lowest speed where maximum g-force is available
    - Minimum altitude lost in recovery
- How Elevator Changes Velocity Vector
    - Controls angle of attack
    - Angle of attack determines magnitude of Lift
    - magnitude of lift controls how quickly the velocity vector changes direction
- How Ailerons Change Velocity Vector
    - Controls rate of roll
        - A new bank angle is selected upon release

Bank angle determines orientation of Lift
Lift orientation controls which direction the velocity vector will change
How Throttles & Drag Devices Change Velocity Vector
Length versus direction
How Rudder Changes Velocity Vector
Indirectly through sideslip
Pitch Stability
Start with an airplane in trim, level flight
The lift is equal to the weight
The Angle of Attack is the angle between the longitudinal axis (or waterline) and the velocity vector
An increase in Angle of Attack results in a lift increase
The lift increase is behind the Center of Gravity
The lift produces a nose down moment, which tends to return the airplane toward the trim angle of attack
CG Effects
Pitch Control Forces
Pitch Trim
Pitch stability
Movement aft
Movement forward
Roll Control
Balance between aileron input, roll inertia, and resistance
Less aileron effectiveness at higher angles of attack
Higher roll inertia reduces susceptibility to wake turbulence
Dutch Roll
Combined rolling and yawing motion due to sideslip
Often has low damping (keeps going)
Roll is primarily due to Dihedral Effect
Coupling Effects
Dihedral Effect
Geometric Dihedral
Wing Sweep
Increases with increasing angle of attack
Adverse Yaw
Yaw due to ailerons/spoilerons
Thrust/Propwash Effects
Pitch/Yawing moments
Gyroscopic effects
Altitude Effects
Coffin Corner
Lower damping
Lower indicated airspeed (less control power)
Higher true airspeed
High Speed Effects
Hinge moment limits

Aerodynamic center shift
Aileron buzz
Buffet
High "g"
Aeroelastic effects
Structural failure
Low Speed Effects
Reduced control effectiveness
Reduced stability (springs and dampers)
Increased dihedral effect
Stall margin
Flow separation
Rudder blanking
Poor Dutch Roll characteristics

3 + 30 - MODULE 4 - Upset Recovery
Basic Recovery Procedures
Control Strategies
ADVANCED CONSIDERATIONS
Examples
Human Factors
UPSET RECOVERY OVERVIEW
Recovery Topics
Recognition
Crew Coordination
Disengage autopilot/autothrottle
Evaluate Flight Condition
Control Strategies
Advanced Considerations
Gotcha's
High/Low speed effects
Non-intuitive Factors
Alternate Controls
Upset Recognition
Upsets occur VERY infrequently
Surprise factor may significantly delay beginning of recovery
Crew Coordination
Announcement of upset recovery procedure
Positive transfer of control
Crosscheck
Limited recovery time may make communication difficult
What can PNF do?
Autopilots/Autothrottles
Components
Sensors
Computer (control laws)

        - Actuators
    - Low redundancy
    - Limited failure monitoring
    - Subject to mode confusion
    - Should be disconnected at first sign of a problem
    - Disengage
        - Transfer Aircraft Control
        - Autopilot
        - Autothrottles
        - Yaw Damper?
    - Evaluate Aircraft Situation
        - Attitude
            - Pitch
            - Bank
        - Velocity Vector
            - Airspeed
            - Angle of Attack
            - Sideslip
        - Altitude
        - Must use instrument references
        - Must crosscheck for erroneous info
            - Pilot vs. Copilot
            - Standby instruments
            - May be acceptable to use outside visual references
        - Some aircraft states must be "inferred"
            - e.g. sideslip
        - Determine Attitude using gyros
            - Sky pointer
            - pitch ladder
            - orientation of labels
            - horizon line
            - sky/ground colors
            - zenith indicator
        - Crosscheck!
    - Determination of Velocity Vector
        - Check Airspeed
        - Check Angle of Attack
            - AOA indicator if available
            - "g" and airspeed combination
            - stick shaker
            - column force
        - Check Sideslip
            - usually no indicator available
            - "ball"
            - sideforce
            - asymmetric thrust
    - Return to Controlled Flight Range

- - Angle of Attack
  - Sideslip
  - Airspeed
- Control Velocity Vector
  - Orient lift vector with bank angle (aileron & rudder)
  - Push or pull as required (elevator)
  - Adjust thrust
- Non-Intuitive Factors
  - Use of full control inputs
  - Use of less than one “g”
  - Use of less than zero “g”
  - Negative training from high performance aircraft
  - Unexpected poor handling qualities
    - high inertia
    - high Mach number
    - low indicated airspeed
  - Distractions
    - improper seat belt restraint
    - flying objects/debris
    - audio warnings
    - warning lights
    - unusual “g” forces (magnitude and direction)
- Use of Alternate Controls
  - Use of Sideslip to Roll
    - rudder
    - split throttle
    - crossover speed
  - Pitch Control
    - banking to get nose down
    - symmetric engines
      - underwing
      - above C.G.
    - split engines
      - Falcon 50
    - spoilers
    - flaps
    - gear
    - stabilizer, trim for primary control
    - C.G. shift
      - passengers
      - fuel
      - load
  - Overspeed Control
    - Engines
    - Spoilers
    - Flaps

- Gear
- Gotcha's
  - Surprise
  - Overreacting
  - Under reacting
  - Improper inputs (wrong way)
  - PIO due to "control delays" during unconventional control strategies
    - Rolling with rudder pedals
    - Engine control
- Pitch Upset - Nose High
  - Disengage autopilot/autothrottle
  - Stop nose up pitch rate (use up to full nose down elevator)
  - If necessary
    - roll up to 60 deg max
    - reduce thrust on underwing engines
    - increase thrust on high mounted engines
  - Approaching horizon, level wings
  - Check airspeed, adjust thrust
  - Adjust pitch attitude
- Pitch Upset - Nose Low
  - Roll to nearest upright bank orientation (sky pointer)
  - Pull nose up to above horizon, use trim if necessary
    - How hard do I pull?
    - Must not hit ground, over g may be required
    - never exceed stall angle of attack
    - be alert to high-speed buffet
  - Reduce thrust
  - Corner speed is optimal
    - If over speed or ground impact anticipated, add drag
- Ice Induced Upset
  - Roll upset
    - Ice ridge ahead of aileron
    - Asymmetric ice accumulation
  - Pitch upset
    - Tailplane stall
- Ice Induced Roll Upset
  - Reduce angle of attack
    - Increase airspeed
    - Extend wing flaps
    - Level wings
  - Set appropriate power
  - Check for ice
    - Do not reduce flaps unless top of wing clear of ice
  - Check ice protection system
    - Ensure functioning symmetrically

- Ice Induced Pitch Upset (Tailplane Stall)
  - Symptoms
    - Trim change
    - Control pulsing (unboosted controls)
    - Pitch down
  - Possible Triggers
    - Flaps extension
    - Airspeed increase
    - Power increase
- Tailplane Stall Upset Recovery
  - Reset flaps
  - Apply nose up elevator pressure
  - Increase airspeed
  - Apply power only as needed

High engine power settings may adversely impact response to tailplane stall conditions at high airspeed in some aircraft

- The "Human Element"
  - Physiological Effects
  - Dealing with the situation
  - Preparation
- Physiological Effects
  - The body's reaction to stress (the "startle factor")
    - Initially response
    - After effects
  - Blocking out the world around you
    - The "soda-straw" effect
  - Tendency to stay with the wrong course of action

Only accept information that supports chosen course

  - The need to do <u>anything</u>
- Dealing with the Situation
  - Verbalize *what* you are doing and *why*
    - Normalizes the cockpit
    - Gets other crewmembers working with you rather than against
  - Reduces startle factor for others
    - Focus you on a solution not on the problem
    - Keeps the channel open
  - Fosters creativity
  - Avoid escalating the situation
- Preparation
  - Can desensitize to some degree
    - Fighter pilots
  - What-if scenarios
    - You build a *library* of possible solutions
    - Allows you to select rather than develop
    - Improves reaction time and increases accuracy

Gaming
Propose
Evaluate
Improve

Day 2 Morning

0 + 0 MODULE 5 - Flight Briefings and Flights

- Aircraft briefings
- Flights

0 + 30 AEROBATIC (BONANZA) FLIGHT SEQUENCE

- Flight Characteristic familiarization
  - Aircraft dynamics
  - Control forces
- Stall characteristics
  - Normal (1g)
  - Accelerated (2g)
  - With and without power
- G-Awareness
- Basic aerobatic maneuvers
  - Barrel roll
  - Aileron roll
  - Loop
  - Split-S
  - Stall-turn
- Basic unusual attitude recoveries
  - Nose high/low
  - Large bank angles
- Advanced unusual attitude recoveries
  - Zero airspeed
  - Accelerated stalls
  - Extreme attitudes

Day 2 Afternoon

In-Flight Simulator (Learjet) Flight Sequence

0 + 45 AERODYNAMICS DEMO

- Aircraft responsiveness and dynamics
- Intro to transport category-handling qualities
- (how a transport is different from an acrobatic aircraft)
  - Slower responses
  - Heavier forces
  - Limited control authority (add control stops)
  - Increased dihedral effect

Roll upset during climb

- CG variations
  - Aft CG
  - Very aft CG

Dutch Roll
- Low damping
- Adverse Yaw
- High dihedral effect

PIO prone aircraft

Unusual Attitudes
- Nose high recoveries
  - Recover elevator only - wings level
    - Unload sensation
- Recover using bank
  - 'g' awareness
  - Risk of "burying the nose"
  - Prudent use of rudders
  - Awareness of dihedral
  - Contrast with Bonanza
- Nose low recoveries
  - Orientation of lift vector
  - 'g' awareness during recovery
  - Speed control
    - Buildup rate (faster than Bonanza)
- IMC recoveries
  - Nose high
  - Nose low
  - Trim Runway

LOFT (Line Oriented Flight Training (LOFT) with failures and upsets)
- Wake turbulence

Pitch trim runaway (pitch upset - nose up)
  - Use bank angle
- Jammed aileron (roll upset)
  - Use rudder
  - Also, possibly differential throttle

Jammed stab. (pitch upset - nose up) (Pitch trim inoperative - must use bank angle)
High forces (use copilot for help)
- Jammed rudder (roll upset)
  - Note roll due to sideslip
  - Discuss crossover speed
- Pitch trim runaway (pitch upset - nose down)
  - Discuss need to control speed and 'g' during recover

Complete hydraulic failure (pitch and roll upset)
  - Control pitch with trim
  - Roll with differential throttles
  - Note lag and tendency to over-control
- Autopilot – rudder hardover (roll upset)
- Autopilot – trim runaway (pitch upset – nose down)
  - With disengage, runaway trim condition worsened
- Misfired shaker/pusher (pitch upset)

Note that any incorrect pilot reaction causes upset

Approach configuration – wake turbulence (roll upset)

Approach configuration – rudder hardover (roll upset)

Note inability to recover until above crossover speed

9. APPENDIX B – COMPLETE RECORDING LIST

Variable	Units	Minimum	Maximum
DIGITAL 1	VOLTS	1.0	0.0
DIGITAL 2	VOLTS	1.0	0.0
DIGITAL 3	VOLTS	1.0	0.0
HOURS	1.2	12.0	:0 hours
MINUTES	3.0	30.0	:0 minutes
SECONDS	3.0	30.0	:0 seconds
MSECONDS	50.0	500.0	:0 mseconds
event_m	0 or 1	1.0	0.0
ap_eng	0 or 1	1.0	0.0
de	deg	5.0	0.0
ds	deg	5.0	0.0
da	deg	5.0	0.0
dr	deg	5.0	0.0
thrust_l	lbs	350.0	0.0
thrust_r	lbs	350.0	0.0
thrust	lbs	700.0	0.0
fes	lb	10.0	0.0
fas	lb	10.0	0.0
frp	lb	20.0	0.0
des	in	1.0	0.0
das	in	10.0	0.0
drp	in	1.0	0.0
desm	in	1.0	0.0
dasm	in	10.0	0.0
drpm	in	1.0	0.0
sys_eng	0 or 1	1.0	0.0
h_cf	ft	2500.0	22000.0
h_dot_cf	ft/s	1000.0	0.0
p	deg/s	10.0	0.0
q	deg/s	4.0	0.0
r	deg/s	4.0	0.0
phi	deg	20.0	0.0
theta	deg	10.0	0.0
psi	deg	20.0	180.0
alpha_cfa	deg	2.0	0.0
alpha_cf	deg	2.0	0.0
beta_cfa	deg	2.0	0.0
beta_cf	deg	2.0	0.0
nx	g	1.0	0.0
ny	g	1.0	0.0
nz	g	1.0	0.0

Variable	Units	Minimum	Maximum
nzp	g	1.0	0.0
vi	knots	25.0	250.0
vt	knots	25.0	250.0
gamma	deg	2.0	0.0
fuel_total	lb	700.0	3500.0
fuel_fuse	lb	150.0	0.0
weight	lb	500.0	12000.0
cg	macs	0.1	0.0
Ixx	slug-ft^2	10000.0	0.0
Iyy	slug-ft^2	10000.0	0.0
Izz	slug-ft^2	10000.0	0.0
Ixz	slug-ft^2	500.0	0.0
hp_ana	ft	5000.0	22000.0
hp	ft	2500.0	22000.0
qci	psf	25.0	250.0
ps	psf	250.0	0.0
temp	degk	12.0	280.0
vi_ana	fps	40.0	0.0
p_mrd	deg/s	10.0	0.0
q_md	deg/s	4.0	0.0
r_mrd	deg/s	4.0	0.0
alpha_vc	deg	2.0	0.0
alphadotia	deg/s	4.0	0.0
alpha_I	deg	2.0	0.0
alp_dot_I	deg/s	4.0	0.0
beta_vc	deg	2.0	0.0
betadotia	deg/s	4.0	0.0
betadot_I	deg/s	4.0	0.0
h_radar	ft	500.0	0.0
mach	nond	1.0	0.0
qbar	psf	25.0	250.0
hdot_dot_I	ft/s/s	15.0	0.0
v_cf	ft/s	100.0	500.0
v_dot_I	ft/s/s	3.0	0.0
v_gust	ft/s	1.0	0.0

10. APPENDIX C – POST EVALUATION FLIGHT QUESTIONNAIRE

Background

Subject ID: ______________________________

Number of Flight Hours: ______________________________

List of Aircraft Types Flown: ______________________________

____

When did you last perform (e.g., two weeks ago, six months ago, 3 years ago)

- Aileron Roll ______________________________
- Barrel Roll ______________________________
- Chandelle ______________________________
- Cloverleaf ______________________________
- Cuban Eight ______________________________
- Immelmann ______________________________
- Lazy Eight ______________________________
- Loop ______________________________
- Split S ______________________________
- Stall Turn ______________________________
- In Airshows ______________________________

Have You Performed Demonstrations or Airshows in an Aircraft with an FAA Aerobatic Waiver:

- ☐ No
- ☐ Yes. If yes, the most recent dates ________________total hours________

If you have had previous airplane upset training:

1. Did the airline have a formal upset training academic program?:
   - ☐ No
   - ☐ Yes. If yes, how many hours ________________?
2. Did the airline include upset training in transition training?:
   - ☐ No
   - ☐ Yes.
   - ☐ Don't know
3. Was upset training repeated during each recurrent cycle?:
   - ☐ No
   - ☐ Yes
   - ☐ Don't know
4. Were the simulators used for the airplane-upset training:
   - ☐ Owned
   - ☐ Leased
   - ☐ Don't know
5. Did the airline instructors receive specific training for airplane upsets?:
   - ☐ No
   - ☐ Yes
   - ☐ Don't know

Ratings

Please rate the following on a scale of 1 (low) to 10 (high):

Confidence to Recover from an Airplane Upset ______

Value of the Aerobatic Experience ______

Value of the Simulator Training ______

Value of the In-flight Training ______

Desire to Obtain More Training ______

Difficulty of the Airplane Recoveries:

Weather (Birmingham) ______

Assuming control (Toledo) ______

Mode awareness (Nagoya) ______

Icing with roll (Roselawn) ______

Icing without roll (Detroit) ______

Inadvertent Slat Deployment (Shemya) ______

Microburst (Charlotte) ______

Rudder Hardover (Pittsburgh) ______

Rankings

Please rank order from 1 (best) to 4 (worst) training ability of pilots to successfully recover an aircraft after an upset:

Aerobatic experience ______

Simulator training ______

Aerobatic experience with simulator training ______

In-flight training ______

Additional Comments

______

11. APPENDIX D – SAFETY PILOT AND FLIGHT ENGINEER SCRIPTS

11.1 BIRMINGHAM

11.1.1 Safety Pilot Script

Upset

Uncommanded roll left followed by pitch up in thunderstorm.

Initial Conditions:

- Level Flight
- 8000 ft MSL (or as noted)
- 180 KIAS
- Gear Up
- Flaps Up

SP Procedure:

Heading	Wind Direction + 120°
Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Initial vector from ATC	Acknowledge ATC
Vectors to intercept ILS from ATC	Acknowledge ATC
Upset	Commences after established on intercept
Recovery	Monitor
Event Complete	Declare "Event Complete"
VSS	Disengage

11.1.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 8000 ft MSL (or as noted)
- 180 KIAS
- Gear Up
- Flaps Up

Introduction:

"You are approaching Denver (field elevation 5430 ft MSL) with thunderstorms in the vicinity of the airport. There are reports of moderate to severe turbulence. You are in level flight at 7000 ft MSL, 180 KIAS, with the landing gear and flaps up. The captain

has just made the first call to Approach Control. You are on a heading of (____) degrees manually flying initial vectors for the ILS (____) approach."

FTE Procedure:

Headings	Initial Heading =____ Initial Vector = Initial Heading – 30° =____ Final Vector = Initial Vector - 60° =____ Runway Heading = Final Vector - 30° =____
Introduction	Read
Data	On
VSS	Engaged
Turbulence	Inject "light" turbulence
ATC	"Veridian one zero two, Denver Approach, turn left heading (___). Vectors for the ILS (___) approach. Maintain one eight zero knots."
Bug Settings	
ATC	"Veridian one zero two, you're six miles from the marker, turn left heading (____), maintain seven thousand and one eight zero knots until established on the localizer. Cleared for the ILS (____) approach."
Bug Settings	
Established on heading	Engage ILS
Overlay	Start when on intercept heading (*rec_psi_cf*)
Upset & Recovery	Monitor
Data	Off when "Event Complete"
Comments	Record

11.2 TOLEDO

11.2.1 Safety Pilot Script

Upset

Captain flying missed approach loses situational awareness and over banks. Co-pilot forced to attempt to recover.

Initial Conditions:

- Level Flight
- 7000 ft MSL (or as noted)
- 160 KIAS
- Gear Up
- Flaps Up

SP Procedure:

Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Declare missed approach	"Denver Tower, Veridian one zero two is on the missed."
ATC responds with switch to Departure	Contact Departure
ATC responds with climb instructions	Acknowledge ATC
Climb	VSS autopilot
Throttles	**Increase to maintain 160 KIAS.**
Throttles at level off	**Leave at climb power**
ATC calls for turn	Acknowledge ATC
Upset	Commences
Herman "Beep" + 2 seconds	**"You got it???" (EP has control)**
Recovery	Monitor
Event Complete	Declare "Event Complete"
Recovery Mode Reset	Instruct EP to push green button
VSS	Disengage

11.2.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 7000 ft MSL (or as noted)
- 160 KIAS
- Gear Up

- Flaps Up

Introduction:

"You have just flown two non-precision approaches to Denver (field elevation 5430 ft MSL), each of which resulted in a missed approach. You start the third approach but, after establishing level flight at Minimum Descent Altitude, the Captain declares a missed approach and takes control of the airplane. You are at 400 ft AGL, 160 KIAS, with the landing gear and flaps already up. The Captain has control and is flying the aircraft."

FTE Procedure:

Introduction	Read
Data	On
VSS	Engaged
Engage ILS	
Overlay	Start
ATC	"Veridian one zero two, roger. Contact Departure, one two zero point five."
ATC	"Veridian one zero two, Denver Departure, roger, fly runway heading, climb and maintain eight thousand".
rec_psi_cf	Note
As nose starts pitching down, ATC	"Veridian one zero two, turn left heading (_)." (90° turn)
Upset & Recovery	Monitor
Data	Off
Comments	Record

11.3 SHEMYA

11.3.1 Safety Pilot Script

Upset

High altitude cruise slat deployment. Aircraft on autopilot. Upset starts with uncommanded 5° roll right followed by pitch up then down. Aircraft is destabilized in pitch for the recovery.

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 250 KIAS
- Gear Up
- Flaps Up

SP Procedure:

Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Cruise	60 seconds
Upset	Commences
Recovery	Monitor
Event Complete	Declare "Event Complete"
VSS	Disengage

11.3.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 250 KIAS
- Gear Up
- Flaps Up

Introduction:

"You are up and away in level flight at 39,000 ft and 250 KIAS with the autopilot engaged. You are on a heading of (_____) degrees."

FTE Procedure:

rec_psi_cf	Note
Introduction	Read
rec_cf_alpha	Note
Data	On
VSS	Engaged
VSS Autopilot	Engage (F-10)
stick_shaker_alpha_setting	Set to *rec_cf_alpha* + 1.5
Cruise	30 sec
Overlay	Start
Upset & Recovery	Monitor
Data	Off
Comments	Record

11.4 NAGOYA
11.4.1 Safety Pilot Script

Upset

Pitch up trim runaway on final approach.

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 150 KIAS
- Gear Up
- Flaps 20°

SP Procedure:

Heading	Wind Direction + 120°
Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Initial vectors from ATC	Acknowledge ATC
Vectors to intercept ILS from ATC	Acknowledge ATC
Intercept ILS	Monitor
ATC call to switch to Tower	Acknowledge ATC
Clearance to land	Acknowledge ATC
Upset	Commences when established on ILS
Recovery	Monitor
Event Complete	Declare "Event Complete"
Recovery Mode Reset	Instruct EP to push green button
VSS	Disengage

11.4.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 150 KIAS
- Gear Up
- Flaps 20°

Introduction:

"You are approaching Denver (field elevation 5430 ft MSL). You are in level flight at 7000 ft MSL and 150 KIAS with landing gear up and flaps 20°. The captain has just

made the first call to Approach Control. You are on a heading of (____) degrees manually flying initial vectors for the ILS (____) approach."

FTE Procedure:

Headings	Initial Heading =____ Initial Vector = Initial Heading – 30° =____ Final Vector = Initial Vector - 60° =____ Runway Heading = Final Vector - 30° =____
Introduction	Read
Data	On
VSS	Engaged
ATC	"Veridian one zero two, Denver Approach, turn left heading (___). Vectors for the ILS (____) approach."
Bug Settings	Set
ATC	"Veridian one zero two, you're six miles from the marker, turn left heading (____). Maintain seven thousand until established on the localizer. Cleared for the ILS (____) approach."
Bug Settings	
ATC	"and Veridian one zero two, be advised. You're number two eight miles in trail of a seven four seven heavy on a low approach. Caution wake turbulence."
On intercept heading (*rec_psi_cf*)	Engage ILS
Decision Height	Fixed at 200 ft AGL
ATC	"Veridian one zero two, contact Denver Tower one two four point three."
ATC	"Veridian one zero two, Denver Tower, cleared to land runway (___)."
Established on ILS	Start Overlay
Upset & Recovery	Monitor
Emergency Trim (if requested)	***stab_trim_enable*** = 1.0
Data	Off
Comments	Record

11.5 CHARLOTTE

11.5.1 Safety Pilot Script

Upset

Windshear on final approach.

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 150 KIAS
- Gear Up
- Flaps 20°

SP Procedure:

Heading	Wind Direction + 120°
Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Initial vectors from ATC	Acknowledge ATC
Vectors to intercept ILS from ATC	Acknowledge ATC
Intercept ILS	Monitor
ATC call to switch to Tower	Acknowledge ATC
Clearance to land	Acknowledge ATC
At Minimums	**Hand Signal then Flaps to 0°. When one dot low on GS, call "Windshear."**
Recovery	**Limit throttles to 83% N_1, 1.5 EPR. 140 KIAS minimum.**
Event Complete	Declare "Event Complete"
VSS	Disengage

11.5.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 150 KIAS
- Gear Up
- Flaps 20°

Introduction:

"You are approaching Denver (field elevation 5430 ft MSL) with thunderstorms in the vicinity of the airport. You are in level flight at 7000 ft MSL and 150 KIAS with the landing gear up and flaps 20°. The captain has just made the first call to Approach Control. You are on a heading of (____) degrees manually flying initial vectors for the ILS (____) approach."

FTE Procedure:

Headings	Initial Heading =____ Initial Vector = Initial Heading – 30° =____ Final Vector = Initial Vector - 60° =____ Runway Heading = Final Vector - 30° =____
Introduction	Read
Data	On
VSS	Engaged
ATC	"Veridian one zero two, Denver Approach, turn left heading (___). Vectors for the ILS (____) approach."
Turbulence	Inject "light" turbulence.
Bug Settings	Set
ATC	"Veridian one zero two, you're six miles from the marker, turn left heading (____). Maintain seven thousand until established on the localizer. Cleared for the ILS (____) approach.
Bug Settings	Set
On intercept heading *(rec_psi_cf)*	Engage ILS
Decision Height	Fixed at 200 ft AGL
ATC	"Veridian one zero two, contact Denver Tower one two four point three."
Turbulence	Inject "moderate" turbulence
ATC	"Veridian one zero two, Denver Tower, cleared to land runway (___).
Turbulence	Inject "severe" turbulence
At minimums	**Start Overlay**
SP retracts flaps	**Event Marker (F-12)**
Upset & Recovery	Monitor
Data	Off
Comments	Record

11.6 PITTSBURGH
11.6.1 Safety Pilot Script

Upset

Rudder hardover (nose left).

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 170 KIAS
- Gear Up
- Flaps Up

SP Procedure:

Heading	Wind Direction + 120°
Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Initial vectors from ATC	Acknowledge ATC
Upset	Commences
Recovery	Monitor
Event Complete	Declare "Event Complete"
Recovery Mode Reset	Instruct EP to push green button
VSS	Disengage

11.6.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 170 KIAS
- Gear Up
- Flaps Up

Introduction:

"You are approaching Chicago (field elevation 668 feet). You are in level flight at 5000 ft MSL, 170 KIAS, with the landing gear and flaps up. The Captain has just made the first call to Approach Control. You are on a heading of (____) degrees manually flying initial vectors for the ILS (____) approach."

FTE Procedure:

Headings	Initial Heading =____ Initial Vector = Initial Heading – 30° =____ Runway Hdg = Initial Vector – 90° =____
Introduction	Read
Data	On
VSS	Engaged
ATC	"Veridian one zero two, Chicago Approach, turn left heading (___). Maintain five thousand and one seven zero knots. Vectors for the ILS (____) approach."
Turbulence	Inject "light" turbulence.
Bug Settings	Set
On intercept heading (*rec_psi_cf*)	Start overlay
Upset & Recovery	Monitor
Data	Off
Comments	Record

11.7 ROSELAWN

11.7.1 Safety Pilot Script

<u>Upset</u>

Aileron "snatch" in icing conditions.

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 170 KIAS
- Gear Up
- Flaps 20°

SP Procedure:

Heading	Any
Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Instructions to accelerate from ATC	Acknowledge ATC
Flaps	**Up at 180 KIAS**
Upset	Commences
Recovery	Monitor
Event Complete	Declare "Event Complete"
VSS	Disengage

11.7.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 170 KIAS
- Gear Up
- Flaps 20°

Introduction:

"You are in icing conditions as you approach Chicago (field elevation 668 ft). The aircraft is in level flight at 5000 ft MSL, 170 KIAS, with the landing gear up and flaps already set to 20°. Flap limit speed is 180 knots."

FTE Procedure:

Headings	Initial Heading =____ Initial Vector = Initial Heading – 30° =____ Final Vector = Initial Vector - 60° =____ Runway Heading = Final Vector - 30° =____
Introduction	Read
rec_cf_alpha	Note
Data	On
VSS	Engaged
snatcher_alpha_setting	**Set to *rec_cf_alpha* + 3.0**
Turbulence	Inject "moderate" turbulence
Engage ILS	
Overlay	Start
ATC	"Veridian one zero two, Chicago Approach, maintain five thousand and one eight zero knots for spacing. You'll be number three for the airport."
ATC	"Veridian one zero two, turn right heading (____)." **(90° turn)**
Upset & Recovery	Monitor
Data	Off when "Event Complete"
Comments	Record

11.8 DETROIT
11.8.1 Safety Pilot Script

Upset

Non-linear roll control in icing.

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 190 KIAS
- Gear Up
- Flaps Up

SP Procedure:

Heading	Any
Aircraft	On Condition
Introduction	Read by FTE
VSS	Engage
Instructions to slow from ATC	Acknowledge ATC
Instructions to turn from ATC at 170 KIAS	Acknowledge ATC
Upset (Loss of roll control)	Commences
Recovery	Monitor
Event Complete	Declare "Event Complete"
VSS	Disengage

Note: **NO flaps if requested by EP (i.e. "Let's keep it clean until we get closer")**

11.8.2 Flight Test Engineer Script

Initial Conditions:

- Level Flight
- 9000 ft MSL (or as noted)
- 190 KIAS
- Gear Up
- Flaps Up

Introduction:

"You are in icing conditions as you approach Chicago (field elevation 668 ft MSL). You are at 5000 ft MSL, 190 KIAS, with the landing gear and flaps up. The Captain has already contacted Approach Control. You are on a heading of (____) degrees manually flying initial vectors for the ILS (____) approach."

FTE Procedure:

Headings	Initial Heading =____ Initial Vector = Initial Heading – 30° =____ Final Vector = Initial Vector - 60° =____ Runway Heading = Final Vector - 30° =____
rec_psi_cf	Note
Introduction	Read
rec_cf_alpha	Note
Data	On
VSS	Engaged
model_stall_alpha	Set to ***rec_cf_alpha*** + 1.5
Turbulence	Inject "light" turbulence
ATC	"Veridian one zero two, Chicago Approach, maintain (_heading_) degrees and five thousand. Slow to one five zero knots for spacing."
ATC (**at 170 KIAS** ***rec_vi_lear***)	"Veridian one zero two, Approach, turn left heading (____)."
Bug Settings	Set
Upset & Recovery	Monitor
Data	Off when "Event Complete"
Comments	Record

12. APPENDIX E – RECRUITING FLIER

NEW HIRE PILOTS NEEDED TO EVALUATE TRAINING

Why

Airplane upset accidents, along with controlled flight into terrain (CFIT), are the leading factors in hull losses and fatalities. Combined, these two categories resulted in 4617 fatalities between 1987 and 1996 worldwide among airlines. Given the problem severity, the airplane manufacturers, airlines, pilot associations, flight training organizations, and government regulatory agencies have combined forces to develop an Airplane Upset Recovery Training Aid package that includes text, simulator training, and a video. But does this training really work? ALPA has been an active participant in the evolution of this proposed training and now NASA has funded an in-flight evaluation of the proposed Airplane Upset Training. We are at the stage where a select group of pilots has the opportunity to validate this training in actual flight, to improve their own flying skills, and to contribute to the future safety of air travel. If you meet our criteria (have not had any military pilot training, are still in your probation period with your airline, and are willing to spend one or two days flying a state-of-the-art test aircraft), we would like to hear from you.

What

You would be assigned to one of five groups. The first group, "Untrained," is made up of pilots in their probationary year. These pilots have not had any aerobatic flight experience. The second group, "Untrained with Aerobatic Experience," is made up of pilots in their probationary year at the airline but these pilots have had aerobatic experience. Aerobatic experience is defined as at least six-hours of training completing Aileron Roll, Barrel Roll, Chandelle, Cloverleaf, Cuban Eight, Immelmann, Lazy Eight, Loop, Split S, and Stall Turn maneuvers or experience performing in airshows or stunts in an aircraft with an FAA aerobatic waiver. The third group, "Simulator," is made up of pilots are in their probationary year at the airline and have received airline provided airplane-upset training in both ground school and in the simulator. These pilots do not have any aerobatics training or experience. The fourth group, "Simulator with Aerobatic Experience," has received the same training as group three but in addition have aerobatic flight experience as defined above. The fifth group, "In-flight," is made up of pilots in their probationary year at the airline who will receive special ground school followed by in-flight upset training using an instrumented in-flight simulator, the Veridian Variable Stability Learjet. This last group does not have any aerobatic experience as defined above.

Where

You will be asked to come to Veridian Engineering Flight Research facilities in Buffalo, New York for two flights. The first flight will either be in-flight upset training or a familiarization flight, depending on the group to which you have been assigned. The second flight will be the data collection flight. You will be presented about eight airplane upsets derived from hull loss accidents. These will be as realistic and as comprehensive as the Learjet in-flight simulator is capable of, within the strict bounds of a closely monitored safety of flight program. You will feel the g's, the motions and the control ineffectiveness, just as they appeared to the accident pilots and you will try to recover the aircraft. The Veridian Engineering safety pilot and the automatic safety guards in the aircraft will keep the Lear within safe operating conditions. If either detects the potential

for an unsafe maneuver, control will return to the safety pilot who will bring the aircraft to straight and level flight at a safe altitude. These are the same Learjets that Veridian Engineering has used for the past 20 years to teach aircraft flying qualities and flight control system design to all of the Test Pilots in the USAF and USN as well as in Europe.

Benefits to You

Eight pilots will receive in-flight airplane upset training as part of this study. All forty subjects will safely experience the realism of airplane upsets that resulted in documented hull loss accidents but have been judged as recoverable in subsequent analysis. By all opinions, this exposure will significantly add to your own flying skills and experience.

Confidentiality of Records

All records will be maintained with complete confidentiality. We have been doing these types of tests for the military and for non-military customers for 50 years. Your name will not be associated with any of the data collected. A random number will be assigned to your data. Your name will never be associated with that number. Neither your employer nor the data analyst will have the means to correlate names and results.

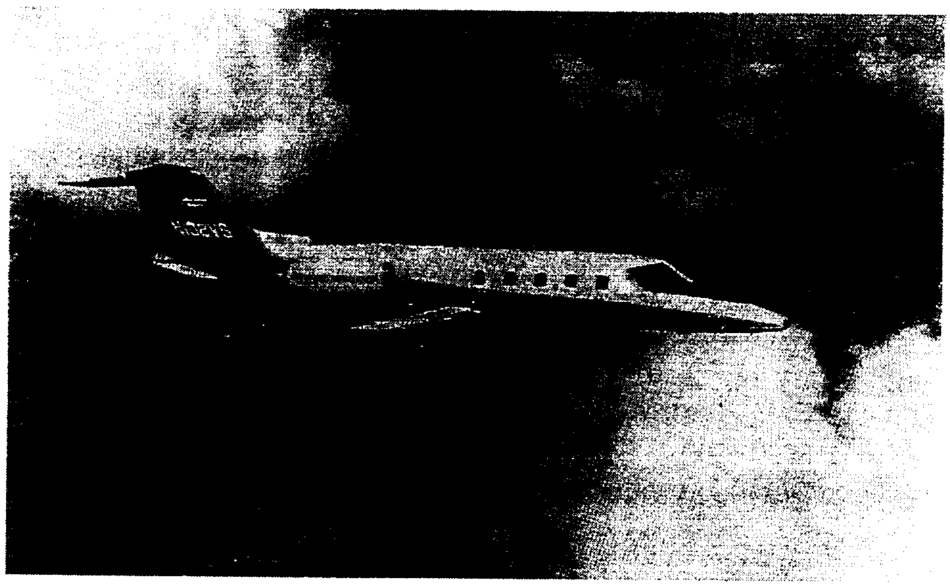
Whom to Contact

We appreciate your interest and value your participation. If you are interested or have further questions, please contact Valerie Gawron:

Veridian Engineering Flight Research Group (formerly Calspan)
150 North Airport Drive
Buffalo, NY 14225
800-225-7726 ext 6916 (voice)
716-631-6990 (fax)
vgawron@buffalo.veridian.com

13. APPENDIX F – RECRUITING POSTER

Pilots Needed for Training Research Project



Background
Airplane manufacturers, airlines, pilot associations, flight training organizations, and government regulatory agencies have combined forces to develop an Airplane Upset Recovery Training Aid package. But does this training really work?

The test
A select group of pilots has the opportunity to validate this training in actual flight, to improve their own flying skills, and to contribute to the future safety of air travel. If you meet our criteria (have not had any military pilot training, are still in your probation period with your airline, and are willing to spend one or two days flying a state-of-the-art test aircraft), we would like to hear from you. We will provide hotel, meals, and local transportation.

Whom to Contact
We appreciate your interest and value your participation. If you are interested or have further questions, please contact Valerie Gawron:

Veridian Engineering Flight Research Group (formerly Calspan)
150 North Airport Drive
Buffalo, NY 14225
800-225-7726 ext 6916 (voice)
716-631-6990 (fax)
vgawron@buffalo.veridian.com

14. APPENDIX G - INFORMED CONSENT

National Aeronautics and Space Administration
Ames Research Center
Moffett field, CA 94035-1000

Human Research Informed Consent

Part 1

Title: Airplane Upset Training Evaluation

A. Purpose

Airplane upset accidents, along with controlled flight into terrain (CFIT), resulted in 4617 fatalities between 1987 and 1996 worldwide among airlines. Combined, these two categories are the leading factors in hull losses and fatalities. Given the problem severity, the airplane manufacturers, airlines, pilot associations, flight training organizations, and government regulatory agencies have combined forces to develop an Airplane Upset Recovery Training Aid package that includes text, simulator training, and a video. While this training package is an improvement over past practices, the motion and visual illusions that are associated with the aircraft upset are beyond the fidelity of current ground simulators. The purpose of this study is to evaluate the benefit of this training.

B. Investigators

Principal Investigator: Valerie J. Gawron, Ph.D.

C. Nature of Test and Experiments

To evaluate airplane upset training, we identified five groups. Each group is composed of eight, male, non-military, new-hire pilots from a single airline. The first group, "Untrained," is made up of pilots prior to the start of their training at the airline. These pilots have not had any aerobatic flight experience. The second group, "Untrained with Aerobatic Experience," is made up of pilots prior to the start of their training at the airline but these pilots have had aerobatic experience. Aerobatic experience is defined as at least six-hours of training completing Aileron Roll, Barrel Roll, Chandelle, Cloverleaf, Cuban Eight, Immelmann, Lazy Eight, Loop, Split S, and Stall Turn maneuvers or experience performing in airshows or stunts in an aircraft with an FAA aerobatic waiver. The third group, "Simulator," is made up of pilots who have started at the airline and have received airplane-upset training in both ground school and in the simulator. These pilots do not have any aerobatics training or experience. The fourth group, "Simulator with Aerobatic Experience," has received the same training as group three but in addition have aerobatic flight experience as defined above. The fifth group, "In-flight," is made up of pilots prior to the start of their training at the airline who receive in-flight airplane upset training using an instrumented in-flight simulator, the Veridian Variable Stability Learjet. This last group does not have any aerobatic experience as defined above.

The pilots in the first four groups will receive a 0.7-hour familiarization flight in the Veridian Variable Stability Learjet. This will equalize the familiarity of these four groups with the fifth group that received in-flight airplane upset training in the Veridian Variable Stability Learjet. Pilots from all five groups will then complete a 1.4-hour flight in which airplane upsets will be introduced during performance of precision instrument control tasks. The upsets will be of three types (environment, component, or

aerodynamic) and will be patterned after hull-loss airplane upset accidents. The objective of this program is to generate data to support decision-making on the part of the FAA for regulation development and the airlines for investment in the proper training practices and procedures to reduce the occurrence of accidents due to airplane upset.

D. Manner in Which Tests will be Conducted

You will be asked to come to Veridian Engineering Flight Research facilities in Buffalo, New York for two flights. The first flight will either be in-flight upset training or a familiarization flight, depending on the group to which you have been assigned. The second flight will be the data collection flight. You will be presented about eight airplane upsets derived from hull loss accidents. You will try to recover the aircraft. The safety pilot and the automatic safe guards in the aircraft will keep the Lear within safe operating conditions. If either detects an unsafe maneuver, control will return to the safety pilot who will bring the aircraft to straight and level flight at a safe altitude. This flight concludes your participation in this study. However, you may be contacted again in the future and asked to participate in a study examining the currency requirements for airplane upset training.

E. Duration

Your participation including travel time is a maximum of two days barring weather or maintenance on the aircraft. If you are in the in-flight training group, you will receive 4 hours of ground school followed by 1.5 hours of in-flight training. If you are in any of the other four groups, you will receive a 45-minute familiarization flight. All groups will receive a 1.4-hour data collection flight.

F. Foreseeable Inconvenience, Discomfort, and Risks

You may experience startle and confusion. In addition, some discomfort may occur during the upset maneuvers due to motion sickness. The flights will be conducted in a Learjet Model 25 registered in the experimental class as a result of the addition of digital fly-by-wire flight test systems and recording equipment. The aircraft is FAA certified and operated under FAR 91. The safety pilots are accredited test pilots with thousands of flight hours. Each safety pilot is also Learjet type rated and undergoes annual FAA proficiency and instrument check rides. There are risks, such as those that may occur in normal aviation flight.

G. Benefits to the Subject or to Others

Eight pilots will receive in-flight airplane upset training as part of this study. All forty subjects will experience airplane upsets that resulted in hull loss accidents but have been judged as recoverable in subsequent analysis. You may become better able to deal with startle and confusion.

H. Confidentiality of Records

All records will be maintained with complete confidentiality. Your name will not be associated with any of the data collected. A random number will be assigned to your data. Your name will never be associated with that number.

I. Compensation

You will receive reimbursement for hotel and per diem costs. No additional reimbursement will be given.

J. Right to Withdraw from the Study and the Penalties/hazards Associated with Withdrawal

Participation is voluntary. You have the right to withdraw from the study at any time for any reason, although we hope that you will not volunteer for the study unless you intend to complete it. There are no penalties or hazards associated with withdrawal at any time during this study.

You will be informed of significant new findings developed during the course of the research that may impact your willingness to participate.

K. Answers to Questions

You may receive answers to any questions related to this study by making contact with the Principal Investigator at (800) 225-7726 ext 6916. Should any problems related to the study occur during its course, please contact the Principal Investigator at that number. Questions or problems regarding your rights as a research participant should be directed to the Human Subjects Review Committee at (716) 645-2711.

L. Remedy in the Event of Injury

You will be covered by casualty insurance during the ground portion of this study and passenger legal liability insurance during the in-flight portion of the study. If you sustain an injury caused by this study, the medical payments coverage you will receive are those currently provided within the terms and conditions of Veridian Flight Research Group's Casualty Insurance. You may have other remedies against other persons or organizations, depending on the circumstances of your injury. Emergency medical services are available from the Buffalo International Airport and three area hospitals each within 15 minutes of the airport. The experimenters will take steps to get necessary emergency assistance by calling 632-3117 on site.

I certify that the series of test for which ______________________________ is to serve as a subject has been explained to him or her in detail.

A copy of this informed consent form will be provided to the subject.

____

Signature of Principal Investigator Date

2. Your signature below will indicate that you have decided to volunteer as a research subject; that your questions have been answered satisfactorily; and that you have read and understood the information provided above.

____

Signature of Research Participant Date

Part 2

TO THE TEST SUBJECT: Read Part 1 carefully. Make sure all your questions have been answered to your satisfaction. Do not sign this form until you have read Part 1 and the Principal Investigator has signed it. You will receive a copy of this consent form.

A. I,______________________________ agree to participate as a subject in the tests and experiments described in Part 1 of this form.

B. I am aware of the possible foreseeable harmful consequences that may result from such participation, and that such participation may otherwise cause me inconvenience and discomfort as described in Part 1.

C. My consent has been freely given. I may withdraw my consent, and thereby withdraw from the study, at any time. I understand (1) that the Principal Investigator may dismiss me from the study if I am not conforming to the requirements of the study as outlined in Part 1; and (2) that the safety check pilot may terminate the study in the event that unsafe conditions develop that cannot be immediately corrected.

D. I am not releasing NASA from liability for any injury arising as a result of these tests. I understand that if I am injured in connection with this experiment, I am covered under Veridian Flight Research Group's Casualty Compensation.

E. I hereby agree that all records collected by NASA in the course of this experiment are available to the Principal Investigator. Any other requests for access to information will require a specific request for release.

F. I understand that I have the right to request the Chair of the Ames Human Research Institutional Review Board (HRIRB) to convene a Board if, at any time, I feel that my rights as a human research subject have been abused or violated.

G. I have had an opportunity to ask questions and I have received satisfactory answers to each question I have asked.

____
Printed Name of Test Subject

______________________________ ______________
Signature of Test Subject Date

______________________________ (____)__________
Address Area Code, telephone number

____
City, State, Zip Code

15. APPENDIX H – BRIEFING GUIDE

Simulated Airplane Description

Size
- Transport Category
- Mid-Size

Aerodynamics
- Low Wing
- Swept Wing
- Flaps only

Engines

- 2-Engine
- Mounted under-wing

Flight Controls

- Wheel/Column with rudder pedals
- Elevator with trimmable horizontal stabilizer
- Trimmable Ailerons. No spoilers.
- Trimmable Rudder
- Yaw Damper
- Autopilot
- Emergency Trim

Airspeeds

V_{NE}	325 KIAS
V_A	210 KIAS (Corner Speed)
V_{XOVER}	210 KIAS
V_{LO}	200 KIAS (Transition)
V_{LE}	250 KIAS (Extended)
V_{F20}	180 KIAS (Flaps 20° or less)
V_{F40}	150 KIAS (Flaps more than 20°)
V_{REF}	As Discussed

Load Factor Limitations

N_Z 0.25g to 2.5g (Flaps Up)
0.25g to 2.0g (Flaps Down)

Crew Complement

Evaluation Pilot

- Right seat
- First Officer

Safety Pilot (SP)

- Left seat
- Captain

Flight Test Engineer (FTE)

- Cabin
- Experiment Director
- Voice of Air Traffic Control (ATC)

Cockpit Protocol

Communication

- SP will handle all communications with actual ATC. Experimental ATC communications will be made on hot mike.

- Experimental call sign is "Veridian 102." (Actual call sign is "Lear 102VS")

Standard Procedures

- Use standard 2-person crew procedures.

- Pilot Not Flying (PNF) works radio, landing gear, and flaps.

- Pilot Flying (PF) may and/or should request flap, landing gear, and throttle changes requiring exact settings (i.e., "Flaps 20°" or "Max Thrust").

Experimental Procedures

- SP may set flaps, spoilers, and/or throttle to another setting for simulation purposes. DO NOT override these settings. Call for what you want.

Cockpit Controls

- Autopilot Disconnect Button
  - ➢ Red master button located on right side of wheel (see photo).
  - ➢ Momentary activation will disconnect autopilot.
  - ➢ Press and hold down will disable the stick pusher/puller and trim.

- Recovery Mode Button
  - ➢ Green button located on left side of wheel (see photo).
  - ➢ Will automatically recover aircraft from any attitude.
  - ➢ Use only when scenario is complete and control forces are still being held.

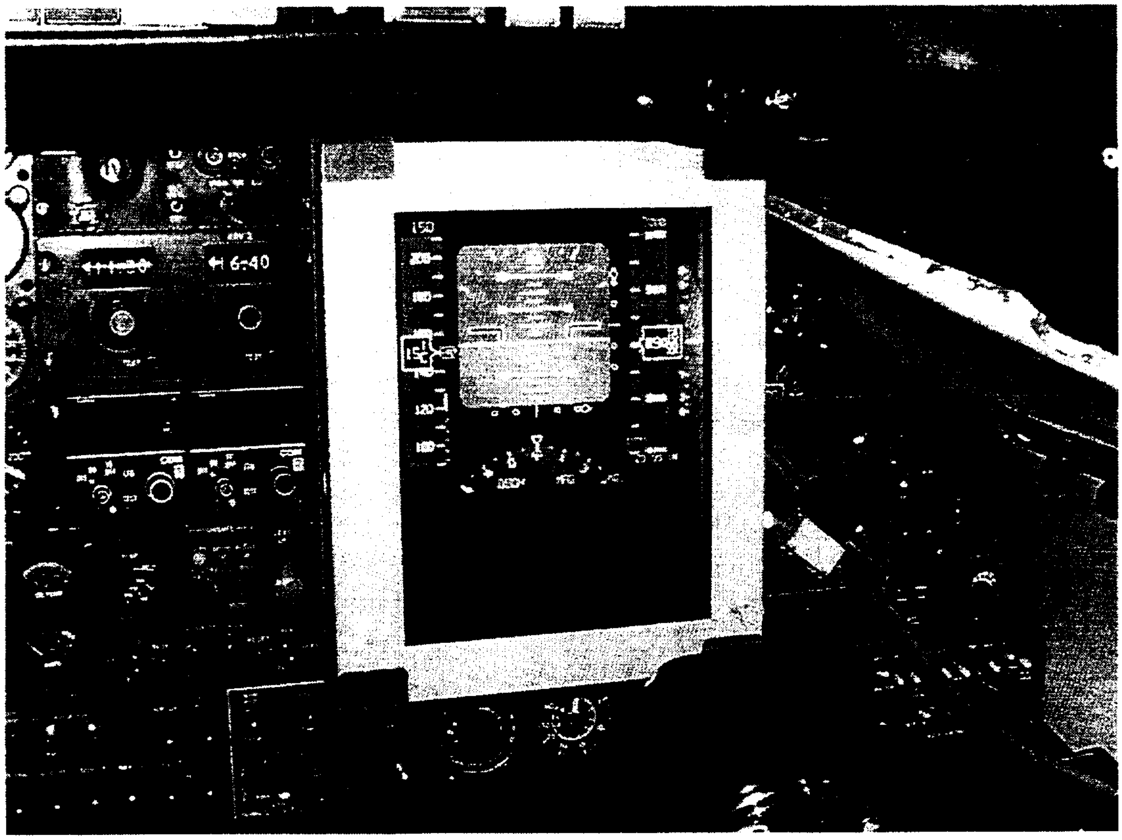
- Variable Stability System (VSS) Disengage Button
  - ➢ Red button located on left side of wheel (see photo).
  - ➢ Will disengage VSS and return control to SP.

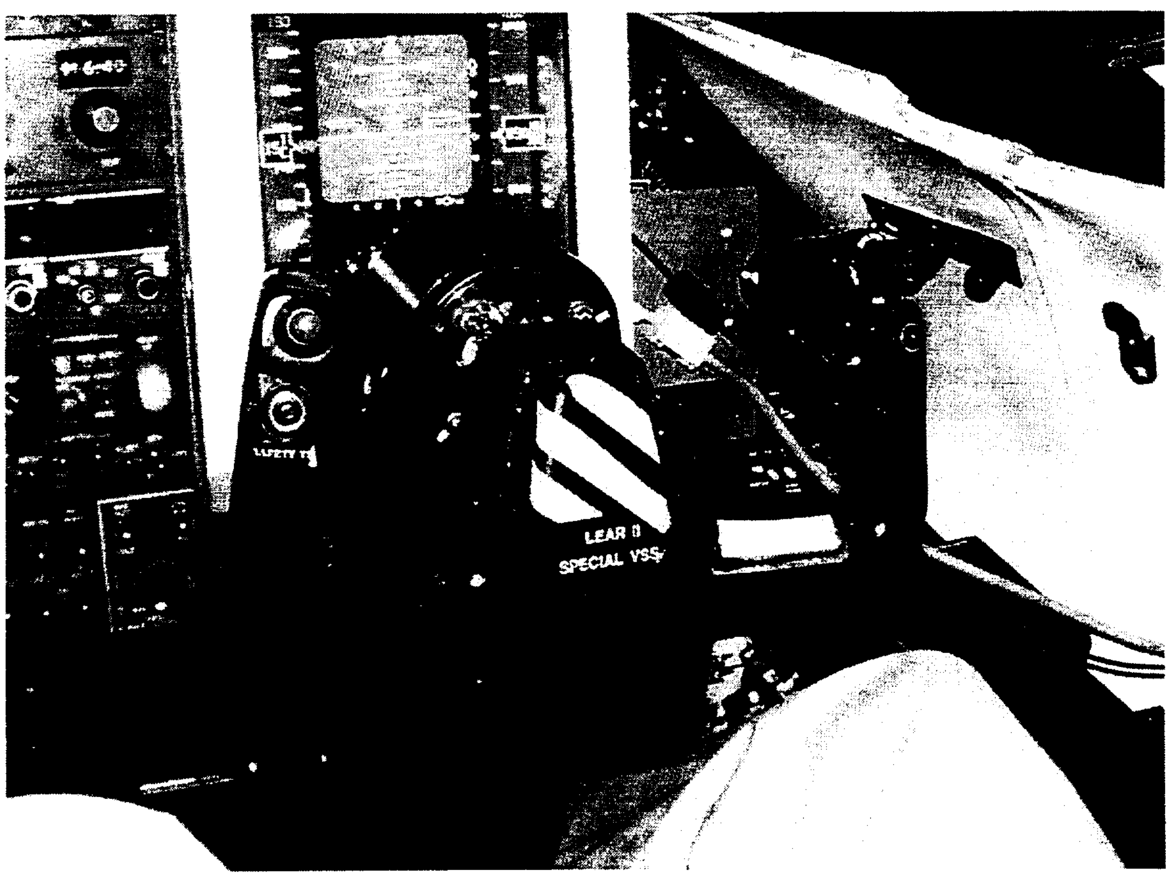
Simulation Scenarios

- 8 scenarios to be flown
  - ➢ Based on actual loss of loss of life accidents from 1991 to present.
  - ➢ All scenarios are in IMC (under the hood).

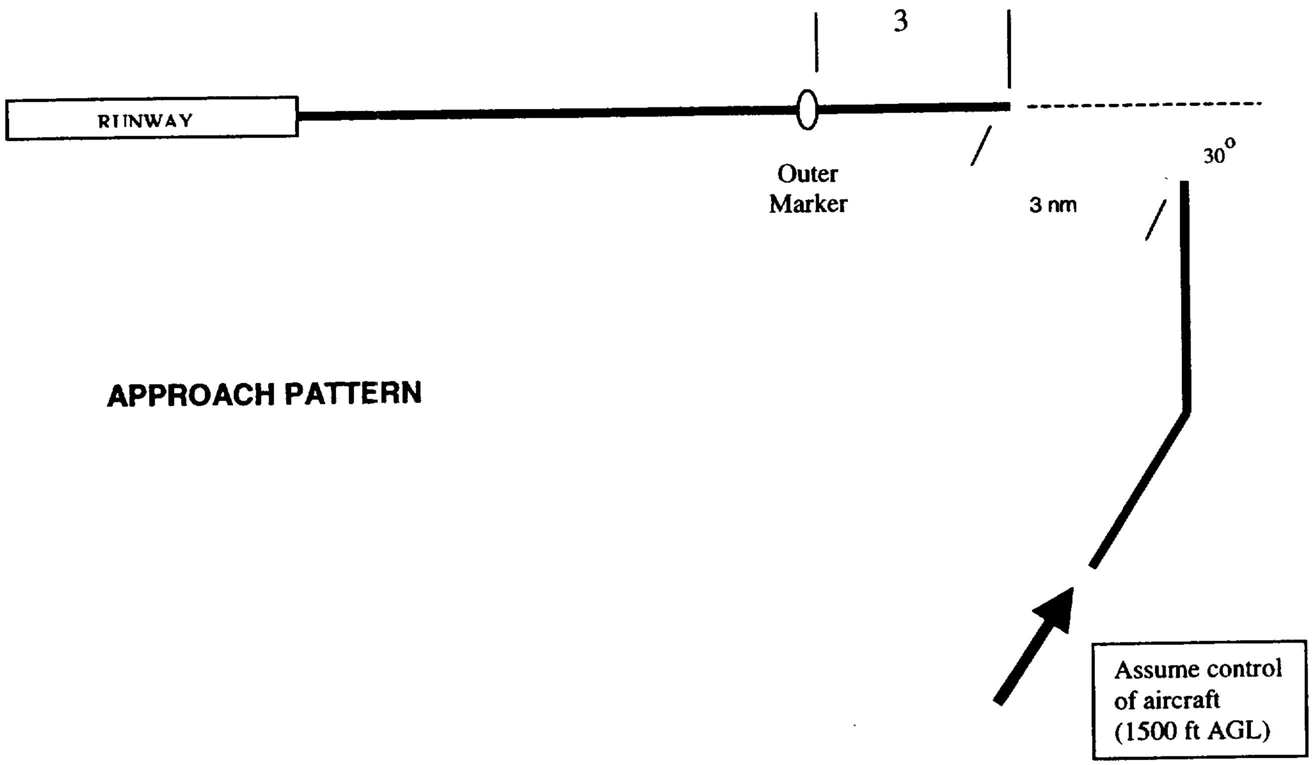
- Simulated approaches and departures to be flown to Chicago O'Hare (low altitude) and Denver (high altitude).
  - ➢ Flown at altitude using ILS-in-the-sky.
  - ➢ ILS needles on flat panel display will be driven to simulate actual approaches.
  - ➢ Call for bug settings as required (altitude, airspeed, heading). Track will also be displayed.

- Approach Description
  - ➢ Will be on initial heading and altitude as scenario begins.
  - ➢ Field elevation will be given in the introduction to the scenario.
  - ➢ ATC will give initial vectors as if you had just entered Approach Control's airspace.
  - ➢ ATC will follow with vectors to intercept the ILS approach. (30° to runway heading, approaching from the left.)
  - ➢ Exact decision height will be given prior to intercepting glideslope.





LEAR
SPECIAL VSS


3
RUNWAY
Outer Marker
30°
3 nm
APPROACH PATTERN
Assume control of aircraft (1500 ft AGL)

16. APPENDIX I – PROTOCOLS

16.1 SUBJECT PROTOCOL

Airplane upset accidents, along with controlled flight into terrain (CFIT), resulted in 4617 fatalities between 1987 and 1996 worldwide among airlines. Combined, these two categories are the leading factors in hull losses and fatalities. Given the problem severity, the airplane manufacturers, airlines, pilot associations, flight training organizations, and government regulatory agencies have combined forces to develop an Airplane Upset Recovery Training Aid package that includes text, simulator training, and a video. While this training package is an improvement over past practices, the motion and visual cues that are associated with the aircraft upset are beyond the fidelity of current ground simulators. Concern must be given to negative transfer-of-training effects based on numerous simulation fidelity studies. A study has never been conducted which proves or disproves the benefit of this training.

This study was reviewed at a workshop attended by twenty-four people representing 15 different organizations. Another 75 people were sent the 3 workshop slides and the draft evaluation plan for comment. All but two did. In all, 31 organizations (3 aircraft manufacturers, 13 airlines, 2 pilot associations, 2 air transport associations, 3 regulatory agencies, 4 pilot training companies, 3 research agencies, and the National Transportation Safety Board (NTSB)) participated. On the basis of this workshop a revised study was designed. The revised study was a between-subjects design with five groups. Each group was composed of eight, non-military, pilots in their probationary year at an airline. Subjects were recruited through the airline training departments using the recruiting flier in Appendix G. Specifically, the flier was sent to each applicant. No coercion of any kind was used. No deception of any kind was used – subjects knew in which group they were participating.

The first group, "Untrained," was made up of pilots prior to the start of their training at the airline. These pilots did not have any aerobatic flight experience. The second group, "Untrained with Aerobatic Experience," was made up of pilots in their probationary year at an airline but these pilots did have aerobatic experience. Aerobatic experience was defined as at least six-hours of training completing Aileron Roll, Barrel Roll, Chandelle, Cloverleaf, Cuban Eight, Immelmann, Lazy Eight, Loop, Split S, and Stall Turn maneuvers or experience performing in airshows or stunts in an aircraft with a Federal Aviation FAA aerobatic waiver. The third group, "Simulator," was made up of pilots who had received airplane-upset training in both ground school and in the simulator. These pilots did not have any aerobatics training or experience. The fourth group, "Simulator with Aerobatic Experience," had received the same training as Group Three but in addition had aerobatic flight experience as defined above. The fifth group, "In-flight," was made up of pilots who received in-flight airplane upset training using an instrumented in-flight simulator, the Veridian Variable Stability Learjet. This last group did not have any aerobatic experience as defined above.

After training, pilots in the first four groups received a 45-minute familiarization flight in the Veridian Variable Stability (VSS) Learjet. This equalized the familiarity of these four groups with the fifth group that received in-flight airplane upset training in the VSS Learjet. Pilots from all five groups then completed an approximately 1.4-hour

evaluation flight in which airplane upsets were introduced during performance of precision instrument control tasks. The upsets were of three types (environment, component/system, or aerodynamic) and were patterned after airplane upset accidents but performed within the safety limitations of the VSS Learjet.

The aircraft attitudes and flight conditions attained during this evaluation were not different than those normally demonstrated in the Veridian Engineering Learjet at the United States Air Force and Naval Test Pilot Schools during the past 20 years. The safety pilot monitored aircraft status and flight condition at all times and disengaged the VSS and recovered to level flight if an unsafe condition was anticipated. The standard VSS automatic safety trips were active during these flights and automatically disengaged the VSS and instantaneously return aircraft control to the safety pilot if any preset value of angle of attack (AOA), G, structural load factor, or undesired control surface activity was reached. The VSS operating envelope was well within the standard Learjet AOA, G, and loads limit envelopes and at no time were those values exceeded. The hazards on these flights were in no way different than were normally encountered on VSS demonstration flights and were, in fact, somewhat reduced as no VSS operations were planned in close proximity to the ground (i.e., normal VSS demos include landings).

To ensure confidentiality of the data, all data records including questionnaires and flight performance were coded with a random number drawn when the subject begin the pre-flight briefing. The subject's name was never attached to the coded number.

The objective of this program was to generate data to support decision-making on the part of the FAA for regulation development and the airlines for investment in the proper training practices and procedures to reduce the occurrence of accidents due to airplane upset.

16.2 NASA PROTOCOL

1. Title: Evaluation of In-flight Airplane Upset Training
2. Organization Location: Veridian Engineering, Flight Research Group, 150 North Airport Drive, Buffalo, NY 14225
3. Principal Investigator: Valerie Gawron, Ph.D.
4. Purpose: To generate data to support decision making on the part of the FAA for regulation development and the airlines for investment in the proper training practices to reduce the occurrence of accidents due to airplane upset.
5. Background: Airplane upset accidents (i.e., controlled flight into terrain and loss-of-control) resulted in 7492 fatalities between 1987 and 1996 worldwide among airlines. Given the problem severity, the airplane manufacturers, airlines, pilot associations, flight training organizations, and government regulatory agencies have banded together to develop an Airplane Upset Recovery Training Aid package that includes text, simulator training, and a video. While this training package is an improvement over past practices, the motion and visual illusions associated with the aircraft upset are beyond the fidelity of current ground simulators. Concern must be given to negative

transfer-of-training effects based on numerous simulation fidelity studies. This study evaluates the benefit of this training.

6. Why human research is required: The study evaluates pilot aircraft upset recovery performance.
7. Plan of Study: This study will be conducted over a 24-month period. The proposed study was reviewed at a workshop attended by twenty-four people representing 15 different organizations. Another 75 people were sent the 3 workshop slides and the draft evaluation plan for comment. All but two did. In all, 31 organizations (3 aircraft manufacturers, 13 airlines, 2 pilot associations, 2 air transport associations, 3 regulatory agencies, 4 pilot training companies, 3 research agencies, and the National Transportation Safety Board (NTSB)) participated. On the basis of this workshop a revised study was designed. The revised study is a between-subjects design with five groups. Each group is composed of eight, non-military, airline pilots in their probationary year. The first group, "Untrained," is made up of pilots who have not had any aerobatic flight experience. The second group, "Untrained with Aerobatic Experience," is made up of pilots who have had aerobatic experience. Aerobatic experience was defined as at least six-hours of training completing Aileron Roll, Barrel Roll, Chandelle, Cloverleaf, Cuban Eight, Immelmann, Lazy Eight, Loop, Split S, and Stall Turn maneuvers or experience performing in airshows or stunts in an aircraft with a Federal Aviation FAA aerobatic waiver. The third group, "Simulator," was made up of pilots who have received airplane-upset training in both ground school and in the simulator. These pilots did not have any aerobatics training or experience. The fourth group, "Simulator with Aerobatic Experience," received the same training as Group Three but in addition had aerobatic flight experience as defined above. The fifth group,. "In-flight," was made up of pilots prior to the start of their training at the airline who received in-flight airplane upset training using an instrumented in-flight simulator, the Veridian Variable Stability Learjet. This last group did not have any aerobatic experience as defined above. After training, pilots in the first four groups received a 45-minute familiarization flight in the Veridian Variable Stability Learjet. This equalized the familiarity of these four groups with the fifth group that received in-flight airplane upset training in the Veridian Variable Stability Learjet. Pilots from all five groups then completed a 1.4-hour evaluation flight in which airplane upsets were introduced during performance of precision instrument control tasks. The upsets were of three types (environment, component, or aerodynamic) and were patterned after hull-loss airplane upset accidents. The objective of this program was to generate data to support decision-making on the part of the FAA for regulation development and the airlines for investment in the proper training practices and procedures to reduce the occurrence of accidents due to airplane upset.
8. Proposed Test Schedule: In May 1999, a workshop was held to finalize airline participation. In summer 2000, airplane upset recovery training was provided and the training was evaluated the Veridian Engineering In-Flight Simulator Learjet.

9. Safety Precautions: Subjects in this study were not exposed to risk beyond that of training or evaluation flight. The NASA Ames safety review was conducted and approval provided.
10. Forty subjects from participating airlines were divided into five equal groups based on the type of training to be provided.
11. Possible inconvenience, discomfort, pain, etc. Subjects experienced maneuvers to mask initial airplane upset conditions and performed aircraft upset recoveries. Some airsickness could have occurred.
12. What measures will be taken to minimize the discomforts or risks. Cabin temperature was kept as low as possible; maneuvers were as subtle as possible.
13. Conditions on withdrawal from the experiment: Subjects were free to withdraw from the study at any time. They were informed of this prerogative when they read and signed the consent form.
14. Subjects were not separately compensated.
15. Compensation in the event of injury. If a subject sustained an injury caused by this study, the medical payments coverage received would have been those currently provided within the terms and conditions of Veridian Flight Research Group's Casualty Insurance. Since subjects were not compensated, Workman's compensation did not apply.
16. Consent form: A copy of the consent form that the subjects were asked to execute is attached.
17. Waivers: None.
18. Designated Responsible Employee: Dr. Key Dismukes was the designated responsible employee for safety of the subjects.

17. APPENDIX J – MATHLAB SCRIPTS FOR DATA REDUCTION

17.1 BIRMINGHAM

```
% Determine event start time index, event end time index & event_time (sec)
%
st=min(find( phi < -30.0 )) - (3.0/0.05);       % start time - 3 seconds
eet_ind=length(time);                          % event end time (index)
t2=time(st:eet_ind);                           % time frame of interest for determining event start
time
t2_ind=min(find( phi(st:eet_ind) < -5.0 ));    % indices in time frame of interest
est=(t2(t2_ind));                              % event start time (sec)
est_ind=find(time==est);                       % event start time (index)

if flight_number == 1506,
 if record_number == 11,
  est = 143.25;
  est_ind = 2866;
 end
end

if flight_number == 1514,
 if record_number == 10,
  est = 143.55;
  est_ind = 2872;
 end
end

if flight_number == 1517,
 if record_number == 10,
  est = 176.75;
  est_ind = 3536;
 end
end

if flight_number == 1521,
 if record_number == 14,
  est = 160.90;
  est_ind = 3219;
 end
end

if flight_number == 1546,
 if record_number == 12,
  est = 100.15;
  est_ind = 2004;
 end
end
```

```
if flight_number == 1549,
 if record_number == 13,
  est = 118.35;
  est_ind = 2368;
 end
end

if flight_number == 1555,
 if record_number == 14,
  est = 78.35;
  est_ind = 1568;
 end
end

if flight_number == 1564,
 if record_number == 12,
  est = 131.35;
  est_ind = 2628;
 end
end

if flight_number == 1576,
 if record_number == 13,
  est = 80.25;
  est_ind = 1606;
 end
end

event_time = time( est_ind:eet_ind );          % event time (sec)
pt_1=est_ind-(10/0.05);                     % time to start time history (sec)
clear st t2 t2_ind est
%
vss_dwn_md=find( sys_eng( est_ind:eet_ind ) < 1 );
if isempty(vss_dwn_md)
 vss_dm=0;
else
 vss_dm=1;
 time_vss_dm=event_time(vss_dwn_md(1));
end
%
% Figure 1a - Event start time & Bank Angle
%
figure(1);clf;subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),time(pt_1:eet_ind),da
(pt_1:eet_ind));ax=axis;
```

```
subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),da(pt_1:eet_ind),'--r',...
            [time(pt_1);time(eet_ind)],[-5;-5],'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 7; Event Start Time is when Phi > -5.0
deg');std_hdr; ylabel('Phi (deg)');
legend('Phi','Delta Ail',3);
if (isempty(est_ind)) == 0
 disp(' ');
 disp([' Event Start Time = ',num2str(time(est_ind)),' seconds']);
 wrt_est=input('  Write Event Start Time on plot ? [<CR> Yes; <1> No]: ');
 if (isempty(wrt_est)) == 1
  gtext([' Event Start Time = ',num2str(time(est_ind)),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0], ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_est
%
% Figure 1b - Master disconnect
%
subplot(212);plot(time(pt_1:eet_ind),ap_eng(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),ap_eng(pt_1:eet_ind),'-
r',time(pt_1:eet_ind),ap_disc(pt_1:eet_ind),'-.b',...
            time(pt_1:eet_ind),sys_eng(pt_1:eet_ind),'--k',[time(est_ind);time(est_ind)],[-
1;3],'-k');
grid on;zoom on;axis([ax(1) ax(2) -1 3]);legend('Auto Pilot Engage','Auto Pilot
Disengage','VSS Engage');
title('Auto Pilot Engage (-r) & Disengage (-.b) & Sys-eng (--k)');ylabel('ap-eng, ap-disc,
sys-eng');
xlabel('Time (sec)');
ap_dis=find( ap_disc( est_ind:eet_ind ) > 0 );
if (isempty(ap_dis)) == 0
 disp(' ');
 disp([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 wrt_ap_dis=input('  Write Auto Pilot Disengage Time on plot ?  [<CR> Yes; <1> No]:
');
 if (isempty(wrt_ap_dis)) == 1
  gtext([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
```

```
text(ax(1)+[( ax(2)-ax(1) )/15.0],2.5,['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax wrt_ap_dis
%
% Figure 2a - First da input
%
figure(2);clf;subplot(211);plot(time(pt_1:eet_ind),fas(pt_1:eet_ind));ax=axis;
plot(time(pt_1:eet_ind),fas(pt_1:eet_ind),'-b',[time(pt_1);time(eet_ind)],[10;10],'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 7; First Definitive Aileron Input is when FAS > 10
lbs');std_hdr; ylabel('FAS (lbs)');
fst_da=find( fas( est_ind:eet_ind ) > 10.0 );
if (isempty(fst_da)) == 0
  disp(' ');
  disp([' First Definitive da input = ',num2str(event_time(fst_da(1))),' seconds']);
  wrt_fst_da=input('  Write da Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_da)) == 1
    gtext([' First Definitive da Input = ',num2str(event_time(fst_da(1))),' seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_da
%
% Figure 2b - First dr input
%
subplot(212);plot(time(pt_1:eet_ind),frp(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),frp(pt_1:eet_ind),'-
b',[time(pt_1);time(eet_ind)],[10;10],'-k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Rudder Input is when FRP > 10 lbs');std_hdr;
ylabel('FRP (lbs)');
xlabel('Time (sec)');
fst_dr=find( frp( est_ind:eet_ind ) > 10.0 );
if (isempty(fst_dr)) == 0
  disp(' ');
  disp([' First Definitive dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
  wrt_fst_dr=input('  Write dr Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_dr)) == 1
    gtext([' First Definitive dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
  end
end
if vss_dm == 1
```

```
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_dr
%
% Figure 3a - First de input
%
figure(3);clf;subplot(211);plot(time(pt_1:eet_ind),de(pt_1:eet_ind),time(pt_1:eet_ind),alp
ha_cf(pt_1:eet_ind),time(pt_1:eet_ind),fes(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),de(pt_1:eet_ind),'-
.r',time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),'--k',time(pt_1:eet_ind),fes(pt_1:eet_ind),'-
b',...
  [time(pt_1);time(eet_ind)],[-10;-10],'-k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-
k');
grid on;zoom on;title('Configuration 7; First Definitive Elevator Input is when FES < -10
lbs');std_hdr; ylabel('FES (lbs)');
legend('Elevator','Alpha','Stk Force',3);
fst_de=find( fes( est_ind+(3.0/0.05):eet_ind ) < -10.0 ); % Automatic de input 3 sec after
event start time
event_time_3=time(est_ind+(3.0/0.05):eet_ind);
if (isempty(fst_de)) == 0
 disp(' ');
 disp([' First Definitive Nose Down de Input = ',num2str(event_time_3(fst_de(1))),'
seconds']);
 wrt_fst_de=input(' Write de Input Time on plot ? [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_de)) == 1
  gtext([' First Definitive Nose Down de Input = ',num2str(event_time_3(fst_de(1))),'
seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_de event_time_3
%
% Figure 3b - First Trim Input
%
trim_strim=stab_trim(est_ind);
subplot(212);plot(time(pt_1:eet_ind),stab_trim(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),stab_trim(pt_1:eet_ind),'-
b',[time(pt_1);time(eet_ind)],[trim_strim+3.0;trim_strim+3.0],'-k',...
[time(est_ind);time(est_ind)],[-2;8],'-k');
```

```
grid on;zoom on;title('First Definitive Trim Input is when Trim > Delta 3.0 deg');std_hdr;
ylabel('Stab Trim (deg)');
xlabel('Time (sec)');
fst_trm=find( stab_trim( est_ind:eet_ind ) > trim_strim+5.0 );
if (isempty(fst_trm)) == 0
  disp(' ');
  disp([' First Definitive Trim Input = ',num2str(event_time(fst_trm(1))),' seconds']);
  wrt_fst_trm=input('  Write Trim Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_trm)) == 1
    gtext([' First Definitive Trim Input = ',num2str(event_time(fst_trm(1))),' seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_trm
%
% Figure 4a - Phi
%
figure(4);clf;subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 7; Phi - Gamma');std_hdr; ylabel('Phi (deg)');
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax
%
% Figure 4b - Gamma
%
subplot(212);plot(time(pt_1:eet_ind),gamma(pt_1:eet_ind),time(pt_1:eet_ind),theta(pt_1:
eet_ind),time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),gamma(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),theta(pt_1:eet_ind),'--b',time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),'-
.r',...
[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;std_hdr; ylabel('Gamma - Theta - Alpha (deg)');xlabel('Time
(sec)');legend('Gamma','Theta','Alpha',3);
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
```

```
end
clear ax
%
% Figure 5a - vi
%
figure(5);clf;subplot(211);plot(time(pt_1:eet_ind),vi(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),vi(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 7; Indicated Velocity - Nz');std_hdr; ylabel('Velocity
(KIAS)');
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax
%
% Figure 5b - Nz
%
nz_corr=-nz;
subplot(212);plot(time(pt_1:eet_ind),nz_corr(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),nz_corr(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;std_hdr; ylabel('Nz Corrected (g)');
xlabel('Time (sec)');
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax nz_corr
%
% Print orientation & Print option
%
for i=1:5,
  figure(i);orient('landscape');
end
%
disp(' ');
disp(' ');
prt = input(' Print Figures 1-5 ?  [<CR> Yes; <1> No]: ');
if (isempty(prt)) == 1
  for i=1:5;figure(i);print;end;
end
```

17.2 TOLEDO

```
% Determine Event start time, Event end time & define Event_time
%
est=find( phi < -5.0 );
%
if flight_number == 1501
 if record_number == 6
  est(1) = 1217;
 end
end
%
if flight_number == 1501
 if record_number == 8
  est(1) = 1013;
 end
end
%
eet=size(time);eet=eet(1);
event_time = time( est(1):eet );
%
vss_dwn_md=find( sys_eng( est(1):eet ) < 1 );
if isempty(vss_dwn_md)
 vss_dm=0;
else
 vss_dm=1;
 time_vss_dm=event_time(vss_dwn_md(1));
end
%
% Figure 1a - Event start time & Bank Angle
%
figure(1);clf;subplot(211);plot(time,phi);ax=axis;
subplot(211);plot(time,phi,'-b',[time(1);max(time)],[-5;-5],'-
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Event Start Time is when Phi > -5.0 deg');std_hdr; ylabel('Phi
(deg)');
if (isempty(est)) == 0
 disp(' ');
 disp([' Event Start Time = ',num2str(time(est(1))),' seconds']);
 wrt_est=input(' Write Event Start Time on plot ? [<CR> Yes; <1> No]: ');
 if (isempty(wrt_est)) == 1
  gtext([' Event Start Time = ',num2str(time(est(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
```

```
 text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax wrt_est
%
% Figure 1b - Master disconnect
%
subplot(212);plot(time,ap_eng);ax=axis;
subplot(212);plot(time,ap_eng,'-r',time,ap_disc,'-.b',time,sys_eng,'--
k',[time(est(1));time(est(1))],[-1;3],'-k');
grid on;zoom on;axis([ax(1) ax(2) -1 3]);legend('Auto Pilot Engage','Auto Pilot
Disengage','VSS Engage');
title('Auto Pilot Engage (-r) & Disengage (-.b) & Sys-eng (--k)');ylabel('ap-eng, ap-disc,
sys-eng');
xlabel('Time (sec)');
ap_dis=find( ap_disc( est(1):eet ) > 0 );
if (isempty(ap_dis)) == 0
 disp(' ');
 disp([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 wrt_ap_dis=input('  Write Auto Pilot Disengage Time on plot ?  [<CR> Yes; <1> No]:
');
 if (isempty(wrt_ap_dis)) == 1
  gtext([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(3,2.5,['VSS Downmode at ',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_ap_dis
%
% Figure 2a - First da input
%
figure(2);clf;subplot(211);plot(time,fas);ax=axis;
plot(time,fas,'-b',[time(1);max(time)],[10;10],'-
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Aileron Input is when FAS > 10 lbs');std_hdr;
ylabel('FAS (lbs)');
fst_da=find( fas( est(1):eet ) > 10.0 );
if (isempty(fst_da)) == 0
 disp(' ');
 disp([' First Definitive da input = ',num2str(event_time(fst_da(1))),' seconds']);
 wrt_fst_da=input('  Write da Input Time on plot ?  [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_da)) == 1
  gtext([' First Definitive da Input = ',num2str(event_time(fst_da(1))),' seconds']);
 end
```

```
end
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax wrt_fst_da
%
% Figure 2b - First dr input
%
subplot(212);plot(time,frp);ax=axis;
subplot(212);plot(time,frp,'-b',[time(1);max(time)],[10;10],'-
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Rudder Input is when FRP > 10 lbs');std_hdr;
ylabel('FRP (lbs)');
xlabel('Time (sec)');
fst_dr=find( frp( est(1):eet ) > 10.0 );
if (isempty(fst_dr)) == 0
  disp(' ');
  disp([' First Definitive dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
  wrt_fst_dr=input(' Write dr Input Time on plot ? [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_dr)) == 1
    gtext([' First Definitive dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax wrt_fst_dr
%
% Figure 3a - First Throttle Input
%
trim_thrust=thrust(est(1));
figure(3);clf;subplot(211);plot(time,thrust);ax=axis;
subplot(211);plot(time,thrust,'-b',[time(1);max(time)],[trim_thrust-125;trim_thrust-125],'-
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Throttle Input is when Delta Thrust > -125
lbs');std_hdr;
ylabel('Total Thrust (lbs)');
%
% Thrust plus 100 lbs
%
%fst_dpthr=find( thrust( est(1):eet ) > trim_thrust+100.0 );
%if (isempty(fst_dpthr)) == 0
```

```
% disp(' ');
% disp([' First Definitive Positive Throttle Input = ',num2str(event_time(fst_dpthr(1))),'
seconds']);
% wrt_fst_dpthr=input('  Write dpthr Input Time on plot ?  [<CR> Yes; <1> No]: ');
% if (isempty(wrt_fst_dpthr)) == 1
%   gtext([' First Definitive Positive Throttle Input =
',num2str(event_time(fst_dpthr(1))),' seconds']);
% end
%end
%
% Thrust minus 125 lbs
%
fst_dnthr=find( thrust( est(1):eet ) < trim_thrust-125.0 );
if (isempty(fst_dnthr)) == 0
 disp(' ');
 disp([' First Definitive Negative Throttle Input = ',num2str(event_time(fst_dnthr(1))),'
seconds']);
 wrt_fst_dnthr=input('  Write dnthr Input Time on plot ?  [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_dnthr)) == 1
  gtext([' First Definitive Negative Throttle Input = ',num2str(event_time(fst_dnthr(1))),'
seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax fst_dpthr wrt_fst_dpthr fst_dnthr wrt_fst_dnthr
%
% Figure 3b - Conner Speed
%
subplot(212);plot(time,vi);ax=axis;
subplot(212);plot(time,vi,'-b',[time(1);max(time)],[210;210],'-
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Corner Speed / Indicated Velocity - KIAS');std_hdr;
ylabel('Velocity (KIAS)');
text(3,204,' Corner Speed = 210 KIAS ');
xlabel('Time (sec)');
if vss_dm == 1
 ax=axis;
 text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax
%
```

```
% Figure 4a - First de input
%
figure(4);clf;subplot(211);plot(time,fes);ax=axis;
subplot(211);plot(time,fes,'-b',[time(1);max(time)],[10;10],'-
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Elevator Input is when FES > 10 lbs');std_hdr;
ylabel('FES (lbs)');
fst_de=find( fes( est(1):eet ) > 10.0 );
if (isempty(fst_de)) == 0
  disp(' ');
  disp([' First Definative de Input = ',num2str(event_time(fst_de(1))),' seconds']);
  wrt_fst_de=input('  Write de Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_de)) == 1
    gtext([' First Definative de Input = ',num2str(event_time(fst_de(1))),' seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax wrt_fst_de
%
% Figure 4b - First Trim Input
%
trim_strim=stab_trim(est(1));
subplot(212);plot(time,stab_trim);ax=axis;
subplot(212);plot(time,stab_trim,'-
b',[time(1);max(time)],[trim_strim+5.0;trim_strim+5.0],'-k',[time(est(1));time(est(1))],[-
2;8],'-k');
grid on;zoom on;title('First Definitive Trim Input is when Trim > Delta 5.0 lbs');std_hdr;
ylabel('Stab Trim (lbs)');
xlabel('Time (sec)');
fst_trm=find( stab_trim( est(1):eet ) > trim_strim+5.0 );
if (isempty(fst_trm)) == 0
  disp(' ');
  disp([' First Definative Trim Input = ',num2str(event_time(fst_trm(1))),' seconds']);
  wrt_fst_trm=input('  Write Trim Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_trm)) == 1
    gtext([' First Definative Trim Input = ',num2str(event_time(fst_trm(1))),' seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
```

```
end
clear ax wrt_fst_trm
%
% Figure 5a - Max Vertical Acceleration
%
nz_corr=nz*(-1);
nz_event=nz_corr( est(1):eet );
max_nz=max(nz_corr( est(1):eet ));
%
figure(5);clf;subplot(211);plot(time,nz_corr);ax=axis;
subplot(211);plot(time,nz_corr,'-b',[time(1);max(time)],[max_nz;max_nz],'-
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Maximum & Minimum Normal Acceleration');std_hdr; ylabel('nz
(g)');
disp(' ');
disp([' Maximum nz on pullout is ',num2str(max_nz),'g']);
wrt_max_nz=input('  Write max nz on plot ?  [<CR> Yes; <1> No]: ');
if (isempty(wrt_max_nz)) == 1
  gtext([' Maximum nz = ',num2str(max_nz),' g']);
end
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax nz_corr nz_event max_nz wrt_max_nz
%
% Figure 5b - Altitude Lost
%
event_alt=h_cf( est(1):eet );
min_alt=min(event_alt);
alt_lost=event_alt(1)-min_alt;
subplot(212);plot(time,h_cf);ax=axis;
subplot(212);plot(time,h_cf,'-b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Altitude Lost During Event');std_hdr; ylabel('Alt (ft)');
xlabel('Time (sec)');
disp(' ');
disp([' Altitude Lost = ',num2str(alt_lost),' Feet']);
wrt_alt_lst=input('  Write Altitude Lost on plot ?  [<CR> Yes; <1> No]: ');
if (isempty(wrt_alt_lst)) == 1
  gtext([' Altitude Lost = ',num2str(alt_lost),' Feet']);
end
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
```

```
end
clear event_alt min_alt alt_lost ax wrt_alt_lst
%
% Figure 6a - Supporting Information (Theta)
%
figure(6);clf;subplot(311);plot(time, theta);ax=axis;
subplot(311);plot(time, theta,'-b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Pitch Attitude, Flight Path Angle & AOA');std_hdr; ylabel('Theta
(deg)');
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
 seconds']);
end
clear ax
%
% Figure 6b - Gamma
%
subplot(312);plot(time, gamma);ax=axis;
subplot(312);plot(time, gamma,'-b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;ylabel('Gamma (deg)');
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
 seconds']);
end
clear ax
%
% Figure 6c - Alpha
%
subplot(313);plot(time,alpha_cf);ax=axis;
subplot(313);plot(time,alpha_cf,'-b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;ylabel('AOA (deg)');xlabel('Time (sec)');
if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
 seconds']);
end
clear ax
%
% Print orientation & Print option
%
for i=1:6,
  figure(i);orient('landscape');
end
%
```

```
disp(' ');
disp(' ');
prt = input('Print Figures 1-6 ?  [<CR> Yes; <1> No]: ');
if (isempty(prt)) == 1
  for i=1:6;figure(i);print;end;
end
```

17.3 SHEMYA

```
% Determine Event start time, Event end time & define Event_time
%   Event start based on roll inputs on autopilot and bank angle

% first estimate "ZERO" value of roll stick deflection after VSS on
ap_up = find( ap_eng > 0.1 );lat_zero=0;
for x = 1:(0.5*(size(ap_up)))
  lat_ze(x) = dasm(ap_up(x));
end
dasm_zero = mean(lat_ze);  % takes average to get "zero" dasm position
clear x lat_ze;

eet=size(time);eet=eet(1);  % event end time
est=find( dasm > dasm_zero+0.3 ); % start time where threshold exceeded
est_1 = est(1);

event_time = time( est_1:eet );
start=time(est_1);
xmin=start-15;
xmax=time(eet)+2;

disp(['Event Start Time at ',num2str(start),' seconds']);

tim_bank = find( abs(phi) > 5 );
time_5 = time(tim_bank(1));

disp(['5 Deg Bank at ',num2str(time_5),' seconds']);

%
vss_dwn_md=find( sys_eng( est_1:eet ) < 1 );
if isempty(vss_dwn_md)
  vss_dm=0;time_vss_dm = xmax;
else
  vss_dm=1;
  time_vss_dm=event_time(vss_dwn_md(1));
  disp(['**************************************************']);
  disp(['VSS Downmode at ',num2str(time_vss_dm),' seconds']);
  disp(['**************************************************']);
end
if time(eet) - time_vss_dm > 15
```

```
  xmax = time_vss_dm + 10;
end

%
% Figure 1a - Event Start time & LAT Stick Deflection
%
figure(1);clf;subplot(211);plot(time,dasm);ax=axis;
subplot(211);plot(time,dasm,'-b',[time(est_1);time(est_1)],[ax(3);ax(4)],'-
k',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-.k');
grid on;zoom on;title('Event Start Time is when Autopilot Upset Lat Stick Command is
Input');std_hdr; ylabel('Lat Stick Deflection (in)');
axis([xmin xmax ax(3) ax(4)]);
if (isempty(est)) == 0
  disp(' ');
  disp([' Event Start Time = ',num2str(time(est_1)),' seconds']);
  wrt_est=input('  Write Event Start Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_est)) == 1
    gtext([' Event Start Time = ',num2str(time(est_1)),' seconds']);
  end
end
clear ax wrt_est
%
% Figure 1b - Master disconnect
%
subplot(212);plot(time,ap_eng);ax=axis;
subplot(212);plot(time,ap_eng,'-r',time,ap_disc,'-.b',time,sys_eng,'--
k',[time(est_1);time(est_1)],[-1;3],'-k');
grid on;zoom on;axis([ax(1) ax(2) -1 3]);legend('Auto Pilot Engage','Auto Pilot
Disengage','VSS Engage');
title('Auto Pilot Engage (-r) & Disengage (-.b) & Sys-eng (-.k)');ylabel('ap-eng, ap-disc,
sys-eng');
axis([xmin xmax -1 2]);xlabel('Time (sec)');
if vss_dm == 1
  ax=axis;
  text(xmin+3,-0.5,['VSS Downmode at ',num2str(time_vss_dm),' seconds']);
end
ap_dis=find( ap_disc( est_1:eet ) > 0 );
if (isempty(ap_dis)) == 0
  disp(' ');
  disp([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
  wrt_ap_dis=input('  Write Auto Pilot Disengage Time on plot ?  [<CR> Yes; <1> No]:
');
  if (isempty(wrt_ap_dis)) == 1
    gtext([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
  end
else disp(['Master Disconnect NOT Depressed,  Auto Pilot Not Disengaged by Pilot']);
```

```
text(xmin+3,0.5,['Master Disconnect NOT Depressed,  Auto Pilot Not Disengaged by
Pilot']);
end
clear ax wrt_ap_dis
%
% Figure 2a - First definitive aileron input
%
figure(2);clf;subplot(211);plot(time,fas);ax=axis;axis([xmin xmax ax(3) ax(4)]);
plot(time,fas,'-b',[time(est_1);time(est_1)],[ax(3);ax(4)],'-
k',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-.k');
grid on;zoom on;title('First Definitive Roll Input is when FAS > 10 lbs');std_hdr;
ylabel('FAS (lbs)');
axis([xmin xmax ax(3) ax(4)]);
hold on;plot([xmin;xmax],[10;10],':r',[xmin;xmax],[-10;-10],':r');
fst_fas=find( abs(fas( est_1:eet )) > 10.0 );
if (isempty(fst_fas)) == 0
  disp(' ');
  disp([' First Definitive Roll Input = ',num2str(event_time(fst_fas(1))),' seconds']);
  hold on;plot([event_time(fst_fas(1));event_time(fst_fas(1))],[(ax(3));(ax(4))],'--r');
  wrt_fst_da=input('  Write Roll Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_da)) == 1
    gtext([' First Definitive Roll Input = ',num2str(event_time(fst_fas(1))),' seconds']);
  end
end
clear ax wrt_fst_da
%
% Figure 2b - Bank Angle
%
subplot(212);plot(time,phi);ax=axis;axis([xmin xmax ax(3) ax(4)]);
plot(time,phi,'-b',[time(est_1);time(est_1)],[ax(3);ax(4)],'-
k',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-.k');
grid on;zoom on;title('Bank Angle Upset from Simulated Asymmetric Slat
Deployment');std_hdr;
ylabel('Bank Angle (deg)'); axis([xmin xmax ax(3) ax(4)]);
text(xmin+3,-0.7,['5 deg Bank at ',num2str(time_5),' seconds']);
%
% Figure 3a - First de input, Pitch Stick Force
%
figure(3);clf;subplot(211);plot(time,fes);ax=axis;
subplot(211);plot(time,fes,'-b',[time(est_1);time(est_1)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Pitch Input is when FES > 10 lbs');std_hdr;
ylabel('FES (lbs)');
axis([xmin xmax ax(3) ax(4)]);xlabel('Time (sec)');
hold on;plot([xmin;xmax],[-10;-10],':r',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-.k');
fst_de=find( fes( est_1:eet ) < -10.0 );
if (isempty(fst_de)) == 0
```

```
 disp(' ');
 disp([' First Definitive de Input = ',num2str(event_time(fst_de(1))),' seconds']);
 plot([event_time(fst_de(1));event_time(fst_de(1))],[30;-30],'--r');
 wrt_fst_de=input(' Write de Input Time on plot ? [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_de)) == 1
  gtext([' First Definitive de Input = ',num2str(event_time(fst_de(1))),' seconds']);
 end
end
clear ax wrt_fst_de
%
% Figure 3b - Pitch Stick Deflection
%
subplot(212);plot(time,desm);ax=axis;
plot(time,desm,'-b',[time(est_1);time(est_1)],[ax(3);ax(4)],'-
k',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-.k');
grid on;zoom on;title('Pitch Inputs Should be Small and Low Frequency');std_hdr;
ylabel('DES (inches)');
axis([xmin xmax ax(3) ax(4)]);

%
% Figure 4a - Altitude
%
figure(4);clf;subplot(211);plot(time,display11);ax=axis;max_alt = max(display11)+100;
min_alt = display11(est_1)-100;
plot(time,display11,[time(est_1);time(est_1)],[ax(3);ax(4)],'-
k',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-.k');
ylabel('Altitude (ft)');grid on;ax=axis;axis([xmin xmax min_alt max_alt]);
title('Look for Signs that Pilot is Chasing Altitude');std_hdr;
hold on;plot([xmin;xmax],[39000;39000],'-.r');
%
% Figure 4b - Nz and Stab Trim
%
subplot(212);plot(time,stab_trim,time,destrimc,'r--',time,nz*-1);ax=axis;
event_nz = -1*nzp(est:eet);max_nz = max(event_nz);min_nz=min(event_nz);
plot(time,stab_trim,'b:',time,destrimc,'r--',time,nzp*-1,'b',time,nz*-1,'k--
',[time(est_1);time(est_1)],[ax(3);ax(4)],'-k',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-
.k');
grid on;zoom on;title(['Stab Trim / Nz. Solid = Pilot Station, Dashed = CG. Max Nz = ',
num2str(max_nz),' g, Min Nz = ',num2str(min_nz),' g']);std_hdr; ylabel('Nz (g) and Stab
Trim');
axis([xmin xmax ax(3) ax(4)]);
fst_trim=find( abs(destrimc( est_1:eet )) > 0.00001 ); % Index of values where stab trim
activated
if (isempty(fst_trim)) == 0
 disp(' ');
 disp(['Time Trim 1st Commanded = ',num2str(event_time(fst_trim(1))),' seconds']);
```

```
  wrt_fst_trim=input('  Write Trim Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_trim)) == 1
    gtext(['Time Trim 1st Commanded = ',num2str(event_time(fst_trim(1))),' seconds']);
  end
end
disp([' ']);
disp(['  Max Nz = ',num2str(max_nz),' g']);
disp([' ']);
disp(['  Min Nz = ',num2str(min_nz),' g']);
disp([' ']);
clear ax wrt_fst_trim
%
% Figure 5a - Pitch attitude
%
figure(5);clf;subplot(211);plot(time,theta);ax=axis;axis([xmin xmax ax(3) ax(4)]);
plot(time,theta,'-b',[time(est_1);time(est_1)],[ax(3);ax(4)],'-
k',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-.k');
grid on;zoom on;title('Pitch Attitude for Relative Magnitude');std_hdr; ylabel('Pitch
Attitude (deg)');
axis([xmin xmax ax(3) ax(4)]);
%
% Figure 5b - AOA and Stick Shaker
%
subplot(212);plot(time,shaker,time,alpha_cf);ax=axis;axis([xmin xmax ax(3) ax(4)]);
plot(time,shaker,'-b',time,alpha_cf,'-r',[time_vss_dm;time_vss_dm],[ax(3);ax(4)],'-
.k',[time(est_1);time(est_1)],[ax(3);ax(4)],'-k');
grid on;zoom on;title(['Stick Shaker Activation and AOA']); ylabel('AOA (deg), Stick
Shaker');
hold on;axis([xmin xmax ax(3) ax(4)]);
fst_shaker=find( abs(shaker( est_1:eet )) > 0.00001 );  % Index of values above stick
shaker
if (isempty(fst_shaker)) == 0
  plot([event_time(fst_shaker(1));event_time(fst_shaker(1))],[0;5],'--r');
  disp(' ');
  disp(['Time Shaker Activated = ',num2str(event_time(fst_shaker(1))),' seconds']);
  wrt_fst_shaker=input('  Write Shaker Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_shaker)) == 1
    gtext(['Time Stick Shaker Activated = ',num2str(event_time(fst_shaker(1))),'
seconds']);
  end
end
clear ax wrt_fst_shaker
%
% Print orientation & Print option
%
for i=1:5,
```

```
 figure(i);orient('landscape');
end
%
disp(' ');
disp(' ');
prt = input('Print Figures 1-5 ?  [<CR> Yes; <1> No]: ');
if (isempty(prt)) == 1
  for i=1:5;figure(i);print;end;
end
```

17.4 NAGOYA

```
subplot(3,1,1);
plot(time, [event_m fes ]);
grid on;

subplot(3,1,2)
plot(time, [event_m stab_trim ap_disc sys_eng gamma]);
grid on;

subplot(3,1,3)
plot(time, [h_cf]);
grid on;

% cfg3a.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to depress master disconnect button.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [event_m ap_disc])
grid on
axis([0 400 -0.5 1.5])
ylabel('Event Marker / Master Disconnect')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3a1.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to depress master disconnect button.
```

```
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [sys_eng de des ap_disc])
grid on
axis([0 400 -4.0 1.5])
ylabel('System Engage / de (deg) / des (deg) / Master Disconnect')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3b.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to exceed 10 lb nose down force on wheel.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [event_m fes])
grid on
axis([0 400 -20 10])
ylabel('Event Marker / fes (lb)')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3b1.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to exceed 10 lb nose down force on wheel.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [sys_eng fes])
grid on
axis([0 400 -20 10])
ylabel('System Engage / fes (lb)')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3c.m
```

```
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to exceed 10 lb roll force on wheel.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [event_m fas phi])
grid on
axis([0 400 -40 40])
ylabel('Event Marker / fas (lb) / phi (deg)')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3c1.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to exceed 10 lb roll force on wheel.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [sys_eng fas phi])
grid on
axis([0 400 -40 40])
ylabel('System Engage / fas (lb) / phi (deg)')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3d.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for airspeed during recovery.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [event_m+150 display02])
grid on
axis([0 400 100 250])
ylabel('Event Marker / Vi (KIAS)')
```

```
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3d1.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for airspeed during recovery.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [sys_eng+150 vi])  % display02
grid on
axis([0 400 100 250])
ylabel('System Engage / Vi (KIAS)')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3e.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to initiate emergency trim.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(time, [event_m destrimc stab_trim])
grid on
axis([0 400 -2.0 1.5])
ylabel('Event Marker / Emer Trim Command / Stab Trim')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')

% cfg3e1.m
%
% Configuration No. 3
% Nagoya A320
%
% Plotting script for time to initiate emergency trim.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
plot(time, [sys_eng destrimc stab_trim])
grid on
axis([0 400 -2.0 1.5])
ylabel('System Engage / Emer Trim Command / Stab Trim')
xlabel('Time (sec)')
std_hdr
title('Nagoya (Cfg 3)')
```

17.5 CHARLOTTE

```
% Determine Event start time, Event end time & define Event_time
%  Event start based on DISPLAYED INDICATED airspeed roll-off
% Create vector that measures airspeed difference over one second (20 samples)
% airspeed drop looks forward 1 second and subtracts the current airspeed
% from the future airspeed.  At 1 second from the end of the record there's no
% future to compare with so airspeed_drop is set to zero for those 20 samples
for i = 1:(size(time))-20
  airspeed_drop(i) = display02(i+20)-display02(i);
end
for i=(size(time))-20:size(time)
  airspeed_drop(i)=0;
end
% Event start time is when the airspeed drop over one second is 10 knots
disp(['**************************************************']);
disp([' ']);
drop_thresh = input('Threshold for Airspeed Drop [<CR> -9.5;]: ');
if (isempty(drop_thresh)) == 1
  drop_thresh = -9.5;
end

est=find( airspeed_drop < drop_thresh );

eet=size(time);eet=eet(1);  % event end time
event_time = time( est(1):eet );
start=time(est(1));
xmin=start-15;
xmax=time(eet)+2;

%
vss_dwn_md=find( sys_eng( est(1):eet ) < 1 );
if isempty(vss_dwn_md)
  vss_dm=0;
else
  vss_dm=1;
  time_vss_dm=event_time(vss_dwn_md(1));
  disp(['**************************************************']);
```

```
  disp(['VSS Downmode at ',num2str(time_vss_dm),' seconds']);
  disp(['***********************************************']);
 end

 %
 % Figure 1a - Event Start time & Indicated Airspeed
 %
 figure(1);clf;subplot(211);plot(time,display02);ax=axis;
 subplot(211);plot(time,display02,'-b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
 grid on;zoom on;title('Event Start Time is when Displayed Airspeed Drops 10
 Knots/sec');std_hdr; ylabel('KIAS');
 axis([xmin xmax ax(3) ax(4)]);
 if (isempty(est)) == 0
  disp(' ');
  disp([' Event Start Time = ',num2str(time(est(1))),' seconds']);
  wrt_est=input('  Write Event Start Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_est)) == 1
   gtext([' Event Start Time = ',num2str(time(est(1))),' seconds']);
  end
 end
 if vss_dm == 1
  ax=axis;
  text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
 seconds']);
 end
 clear ax wrt_est
 %
 % Figure 1b - Master disconnect
 %
 subplot(212);plot(time,ap_eng);ax=axis;
 subplot(212);plot(time,ap_eng,'-r',time,ap_disc,'-.b',time,sys_eng,'--
 k',[time(est(1));time(est(1))],[-1;3],'-k');
 grid on;zoom on;axis([ax(1) ax(2) -1 3]);legend('Auto Pilot Engage','Auto Pilot
 Disengage','VSS Engage');
 title('Auto Pilot Engage (-r) & Disengage (-.b) & Sys-eng (--k)');ylabel('ap-eng, ap-disc,
 sys-eng');
 axis([xmin xmax -1 2]);xlabel('Time (sec)');
 ap_dis=find( ap_disc( est(1):eet ) > 0 );
 if (isempty(ap_dis)) == 0
  disp(' ');
  disp([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
  wrt_ap_dis=input('  Write Auto Pilot Disengage Time on plot ?  [<CR> Yes; <1> No]:
 ');
  if (isempty(wrt_ap_dis)) == 1
   gtext([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 end
```

```
end
if vss_dm == 1
  ax=axis;
  text(xmin+3,-0.5,['VSS Downmode at ',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_ap_dis
%
% Figure 2a - First definitive thrust input
%
figure(2);clf;subplot(211);plot(time,thrust);ax=axis;axis([xmin xmax ax(3) ax(4)]);
thrust_diff=thrust( est(1):eet )-thrust(est(1));fst_thrust=find( thrust_diff > 200.0 );
plot(time,thrust,'-b',[start+1;start+10],[(thrust(est(1))+200);(thrust(est(1))+200)],'--
r',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
hold on;plot([event_time(fst_thrust(1));event_time(fst_thrust(1))],[(ax(3));(ax(4))],'--r');
grid on;zoom on;title('First Definitive Throttle is when Delta Thrust > 200 lbs');std_hdr;
ylabel('Thrust (lbs)');
axis([xmin xmax ax(3) ax(4)]);
if (isempty(fst_thrust)) == 0
  disp(' ');
  disp([' First Definitive Thrust input = ',num2str(event_time(fst_thrust(1))),' seconds']);
  wrt_fst_da=input('   Write Thrust Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_da)) == 1
    gtext([' First Definitive Thrust Input = ',num2str(event_time(fst_thrust(1))),'
seconds']);
  end
end
clear ax wrt_fst_da
%
% Figure 2b - First de input
%
subplot(212);plot(time,fes);ax=axis;
subplot(212);plot(time,fes,'-b',[time(1);max(time)],[10;10],'--
k',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Pitch Input is when FES > 10 lbs');std_hdr;
ylabel('FES (lbs)');
axis([xmin xmax ax(3) ax(4)]);xlabel('Time (sec)');
fst_de=find( fes( est(1):eet ) > 10.0 );
if (isempty(fst_de)) == 0
  disp(' ');
  disp([' First Definitive de Input = ',num2str(event_time(fst_de(1))),' seconds']);
  wrt_fst_de=input('   Write de Input Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_de)) == 1
    gtext([' First Definitive de Input = ',num2str(event_time(fst_de(1))),' seconds']);
  end
end
clear ax wrt_fst_de
```

```
%
% Figure 3a - Attain 15 deg pitch attitude
%
figure(3);clf;subplot(211);plot(time,theta);ax=axis;axis([xmin xmax ax(3) ax(4)]);
fst_theta=find( theta( est(1):eet ) > 15.0 );
plot(time,theta,'-b',[start+1;start+10],[15;15],'--
r',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Pitch Attitude Raised When Theta > 15 deg');std_hdr; ylabel('Pitch
Attitude (deg)');
axis([xmin xmax ax(3) ax(4)]);
if (isempty(fst_theta)) == 0
 disp(' ');
 disp([' Time Theta Attained 15 deg = ',num2str(event_time(fst_theta(1))),' seconds']);
 wrt_fst_theta=input('  Write Theta 15 Time on plot ?  [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_theta)) == 1
   gtext([' Time Theta Attained 15 deg = ',num2str(event_time(fst_theta(1))),' seconds']);
 end
end
clear ax wrt_fst_theta
%
% Figure 3b - AOA and Stick Shaker
%
subplot(212);plot(time,shaker,time,alpha_cf);ax=axis;axis([xmin xmax ax(3) ax(4)]);
fst_shaker=find( abs(shaker( est(1):eet )) > 0.00001 );  % Index of values above stick
shaker
shaker_pct = 100*((size(fst_shaker))/(size(shaker( est(1):eet ))));  % Percent time on
stickshaker
if vss_dm == 1;
  vss_dm_bigtime = vss_dwn_md(1) + est(1) -1;  % VSS downmode in large time frame,
not event timeframe
  fst_shaker = find( abs(shaker( est(1):vss_dm_bigtime )) > 0.00001 );  % Index of values
above stick shaker
  shaker_pct = 100*((size(fst_shaker))/(size(shaker( est(1):vss_dm_bigtime ))));
end
plot(time,shaker,'-b',time,alpha_cf,'-r',[start+1;start+10],[.01;.01],'--
r',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title(['Stick Shaker Activated for = ',num2str(shaker_pct),' % time after
event start']); ylabel('AOA (deg), Stick Shaker');
hold on;axis([xmin xmax ax(3) ax(4)]);
if (isempty(fst_shaker)) == 0
  plot([event_time(fst_shaker(1));event_time(fst_shaker(1))],[(ax(3));(ax(4))],'--r');
  disp(' ');
  disp([' Time Shaker Activated = ',num2str(event_time(fst_shaker(1))),' seconds']);
  wrt_fst_shaker=input('  Write Shaker Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_shaker)) == 1
```

```
    gtext(['Time Stick Shaker Activated = ',num2str(event_time(fst_shaker(1))),'
seconds']);
  end
end
clear ax wrt_fst_shaker
%
% Figure 4a - Hdot
%
figure(4);clf;subplot(211);plot(time,h_dot_cf*60);ax=axis;axis([xmin xmax ax(3)
ax(4)]);
fst_hdot=find( (h_dot_cf( est(1):eet )*60) > 500.0 );
plot(time,h_dot_cf*60,'-b',[start+1;start+30],[500;500],'--
r',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
grid on;zoom on;title('When Hdot > 500 ft/min, Recovery Underway');std_hdr;
ylabel('Climb Rate (ft/min)');
axis([xmin xmax ax(3) ax(4)]);
if (isempty(fst_hdot)) == 0
  hold on;plot([event_time(fst_hdot(1));event_time(fst_hdot(1))],[(ax(3));(ax(4))],'--r');
  disp(' ');
  disp(['Hdot Attained 500 ft/min = ',num2str(event_time(fst_hdot(1))),' seconds']);
  wrt_fst_hdot=input('   Write Hdot 500 Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_hdot)) == 1
    gtext(['Time Hdot Attained 500 ft/min = ',num2str(event_time(fst_hdot(1))),'
seconds']);
  end
end
clear ax wrt_fst_hdot
%
% Figure 4b - Radar Altitude
%
radalt=display14;event_alt=radalt( est(1):eet
);min_alt=min(event_alt);alt_lost=event_alt(1)-min_alt;
subplot(212);plot(time,radalt);ax=axis;
plot(time,radalt,'b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-
k',[start+1;start+30],[min_alt;min_alt],'--r');
axis([xmin xmax 0 1000]);
grid on;zoom on;title(['Simulated Radar Altitude Lost = ',num2str(alt_lost),' Feet']);
std_hdr; ylabel('Radar Altitude (ft)');
disp([' ']);
disp(['  Altitude Lost = ',num2str(alt_lost),' Feet']);
disp([' ']);
%
% Figure 5a - Supplemental Info -- Gamma
%
figure(5);clf;subplot(311);plot(time,gamma);ax=axis;axis([xmin xmax ax(3) ax(4)]);
plot(time,gamma,'-b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
```

```
grid on;zoom on;title('Flight Path Angle');std_hdr; ylabel('Flight Path Angle (deg)');
axis([xmin xmax ax(3) ax(4)]);
%
% Figure 5b - Supplemental Info -- Phi
%
subplot(312);plot(time,phi);ax=axis;
plot(time,phi,'b',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
axis([xmin xmax ax(3) ax(4)]);
grid on;zoom on;title('Bank Angle');std_hdr; ylabel('Bank Angle (deg)');
if vss_dm == 1
 ax=axis;
 text(3,ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax
%
% Figure 5c - Supplemental Info -- TRIM
%
subplot(313);plot(time,stab_trim);ax=axis;
plot(time,stab_trim,'b--',time,destrimc,'r',[time(est(1));time(est(1))],[ax(3);ax(4)],'-k');
axis([xmin xmax ax(3) ax(4)]);
grid on;zoom on;title('Trim and Trim Command');std_hdr; ylabel('Stabilizer Trim (deg)');
clear ax
%
% Print orientation & Print option
%
for i=1:5,
 figure(i);orient('landscape');
end
%
disp(' ');
disp(' ');
prt = input('Print Figures 1-5 ?  [<CR> Yes; <1> No]: ');
if (isempty(prt)) == 1
 for i=1:5;figure(i);print;end;
end
```

17.6 PITTSBURGH

```
% Plotting script for start time, end time, and time to depress master
% disconnect button.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

est = time(find(r <= -2.0))                             % Event start time
eet = time(find(sys_eng < 1.0))                         % Event end time
master_disc = time(find(ap_disc > 0.0))          % Time at depression of master
```

```
                        % disconnect button

plot(time, [r ap_disc sys_eng ])
grid on
axis([0 200 -15.0 15.0])
ylabel('r (deg/sec) / Master Disconnect / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')

% cfg5b.m
%
% Configuration No. 5
% Pittsburgh B-737
%
% Plotting script for time to first drp and das input.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

dt = 0.050;                                             % Data recording rate

fri = time(find(frp >= 10.0))        % Time of first rudder input
fai = time(find(fas >= 10.0))        % Time of first aileron input

plot(time, [ r frp fas sys_eng ])
grid on
axis([0 200 -20.0 100.0])
ylabel('r (deg/sec) / frp (lb) / fas (lb) / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')

% cfg5c.m
%
% Configuration No. 5
% Pittsburgh B-737
%
% Plotting script for time to first correct des input.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

dt = 0.050;                                             % Data recording rate

fei = time(find(fes < -15.0))             % first correct elevator input
phi_at_fes15 = phi(find(fes < -15.0))          % phi at first correct elevator input
```

```
plot(time, [ r fes sys_eng ])
grid on
axis([0 200 -100.0 100.0])
ylabel('r (deg/sec) / fes (lb) / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')

% cfg5d.m
%
% Configuration No. 5
% Pittsburgh B-737
%
% Plotting script for time to phi = -70 deg and elevator input at that point
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

dt = 0.050;                                                          % Data
recording rate

phi70 = time(find(phi < -70.0))          % Time at phi < -70 deg
stick_force = fes(find(phi < -70.0))           % Stick force at phi < -70 deg

plot(time, [ r fes phi sys_eng ])
grid on
axis([0 200 -150.0 100.0])
ylabel('r (deg/sec) / phi (deg) / fes (lb) / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')

% cfg5e.m
%
% Configuration No. 5
% Pittsburgh B-737
%
% Plotting script for time to split throttles, beginning and ending thrust.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

dt = 0.050;
               % Data recording rate

split = time(find((thrust_l-thrust_r) >= 200.0))        % time at thrust split >=200 lb.
```

```
start_thrust = thrust((est(1)*20)+1)                                % Thrust at
beginning of upset.
end_thrust = thrust(eet(1)*20)
        % Thrust at end of upset.

plot(time, [ thrust thrust_l thrust_r sys_eng*100 ])
grid on
%axis([0 200 -120.0 30.0])
ylabel(' thrust (total) (lb) / thrust (left) (lb) / thrust (right) (lb) / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')

% cfg5f.m
%
% Configuration No. 5
% Pittsburgh B-737
%
% Plotting script for airspeed.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%start_airspeed = display02((est(1)*20)+1)  % A/S at start of upset
%end_airspeed = display02(eet(1)*20)                  % A/S at end of upset
%plot(time, [  display02 (sys_eng)+180 ])

start_airspeed = vi((est(1)*20)+1)                  % A/S at start of upset
end_airspeed = vi(eet(1)*20)                                % A/S at end of upset
plot(time, [  vi (sys_eng)+180 ])


grid on
%axis([0 200 -120.0 30.0])
ylabel('airspeed (KIAS) / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')

% cfg5g.m
%
% Configuration No. 5
% Pittsburgh B-737
%
% Plotting script for heading change
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
psis = psi((est(1)*20)+1)                     % Heading at start of upset
```

```
psie = psi(eet(1)*20)                    % Heading at end of upset


plot(time, [ r psi sys_eng*10 ])
grid on
%axis([0 200 0 360])
ylabel('r (deg/sec) / psi (deg) / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')

% cfg5h.m
%
% Configuration No. 5
% Pittsburgh B-737
%
% Plotting script for altitude change
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
alt_start = display11((est(1)*20)+1)                         % Alt at start of upset
alt_end = display11(eet(1)*20)                                            % Alt
at end of upset
alt_min = min(display11((est(1)*20)+1:eet(1)*20)) % Min alt during upset

%alt_start = h_cf((est(1)*20)+1)                                          % Alt
at start of upset
%alt_end = h_cf(eet(1)*20)
        % Alt at end of upset
%alt_min = min(h_cf((est(1)*20)+1:eet(1)*20))            % Min alt during upset
%plot(time, [ h_cf sys_eng*100+8500 ])

plot(time, [ display11 sys_eng*100+5000 ])
grid on
%axis([0 200 0 360])
ylabel('altitude (ft MSL) / System Engage')
xlabel('Time (sec)')
std_hdr
title('Pittsburgh (Cfg 5)')
```

17.7 ROSELAWN

```
% Determine event start time index, event end time index & event_time (sec)
%
st_1=min(find( phi < -30.0 )) - (3.0/0.05);    % start time index for neg roll - 3 seconds
st_2=min(find( phi >  30.0 )) - (3.0/0.05);    % start time index for pos roll - 3 seconds
%
if (isempty(st_1)) == 0
```

```
if (isempty(st_2)) == 0
 if st_1 < st_2,
  st = st_1;
  da_init = da(st);
  bank = -1.0; %negative
 elseif st_2 < st_1,
  st = st_2;
  da_init = da(st);
  bank =  1.0; %positive
 end
else
 st = st_1;
 da_init = da(st);
 bank = -1.0; %negative
end
elseif (isempty(st_2)) == 0
 st = st_2;
 da_init = da(st);
 bank =  1.0; %positive
else
 st = 1;
 da_init = da(st);
 bank = 0.0;
end
%
eet_ind=length(time);                    % event end time (index)
t2=time(st:eet_ind);                     % time frame of interest for determining event start
time
%
if bank == 1.0
 t2_ind=min(find( (da_init - da(st:eet_ind)) >  10.0 ));  % indicies in time frame of
interest
elseif bank == -1.0
 t2_ind=min(find( (da_init - da(st:eet_ind)) < -10.0 ));  % indicies in time frame of
interest
else
 t2_ind = 0;
end
%
est=(t2(t2_ind-(0.25/0.05)));            % event start time (sec) (Selected time - 0.25
sec)
est_ind=find(time==est);                 % event start time (index)
%
% Brute Force Event Start Time
%
if flight_number == 1500,
```

```
  if record_number == 15,
   est = 79.2;
   est_ind=min(find(time > est));
  end
end
%
if flight_number == 1521,
  if record_number == 15,
   est = 87.0;
   est_ind=min(find(time > est));
  end
end
%
if flight_number == 1525,
  if record_number == 7,
   est = 108.05;
   est_ind=min(find(time > est));
  end
end
%
if flight_number == 1526,
  if record_number == 6,
   est = 147.5;
   est_ind=min(find(time > est));
  end
end
%
if flight_number == 1529,
  if record_number == 12,
   est = 119.5;
   est_ind=min(find(time > est));
  end
end
%
if flight_number == 1530,
  if record_number == 6,
   est = 102.2;
   est_ind=min(find(time > est));
  end
end
%
if flight_number == 1534,
  if record_number == 9,
   est = 77.5;
   est_ind=min(find(time > est));
  end
```

```
end
%
if flight_number == 1538,
 if record_number == 9,
  est = 73.4;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1541,
 if record_number == 6,
  est = 50.5;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1542,
 if record_number == 13,
  est = 92.0;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1549,
 if record_number == 7,
  est = 67.5;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1550,
 if record_number == 8,
  est = 50.3;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1559,
 if record_number == 5,
  est = 52.5;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1568,
 if record_number == 5,
```

```
    est = 51.75;
    est_ind=min(find(time > est));
  end
end
%
event_time = time( est_ind:eet_ind );          % event time (sec)
pt_1=est_ind-(8.0/0.05);                   % time to start time history (sec)
clear st_1 st_2 st t2 t2_ind est bank da_init
%
vss_dwn_md=find( sys_eng( est_ind:eet_ind ) < 1 );
if isempty(vss_dwn_md)
  vss_dm=0;
else
  vss_dm=1;
  time_vss_dm=event_time(vss_dwn_md(1));
end
%
% Figure 1a - Event start time & Bank Angle, Aileron Position and Lateral Stick
%
figure(1);clf;subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),time(pt_1:eet_ind),da
(pt_1:eet_ind),...
                   time(pt_1:eet_ind),fas(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),da(pt_1:eet_ind),'--r',...
           time(pt_1:eet_ind),fas(pt_1:eet_ind),'-
.b',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 6; Event Start Time');std_hdr; ylabel('Phi (deg), da,
(deg), Fas (lb)');
legend('Phi','Delta Ail','Lat Stk',4);
%
% look at entire record
%
subplot(212);plot(time,phi,'-k',time,da,'-r',time,fas,'-b');grid;zoom on;
       ylabel('Phi (deg), da, (deg), Fas (lb)');legend('Phi','Delta Ail','Lat Stk',3);
%
if (isempty(est_ind)) == 0
  disp(' ');
  disp([' Event Start Time = ',num2str(time(est_ind)),' seconds']);
  wrt_est=input('   Write Event Start Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_est)) == 1
    gtext([' Event Start Time = ',num2str(time(est_ind)),' seconds']);
  end
end
if vss_dm == 1
  ax=axis;
```

```
 text(ax(1)+[( ax(2)-ax(1) )/15.0], ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_est
%
% Figure 1b - Master disconnect
%
subplot(212);plot(time(pt_1:eet_ind),ap_eng(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),ap_eng(pt_1:eet_ind),'-
r',time(pt_1:eet_ind),ap_disc(pt_1:eet_ind),'-.b',...
          time(pt_1:eet_ind),sys_eng(pt_1:eet_ind),'--k',[time(est_ind);time(est_ind)],[-
1;3],'-k');
grid on;zoom on;axis([ax(1) ax(2) -1 3]);legend('Auto Pilot Engage','Auto Pilot
Disengage','VSS Engage');
title('Auto Pilot Engage (-r) & Disengage (-.b) & Sys-eng (--k)');ylabel('ap-eng, ap-disc,
sys-eng');
xlabel('Time (sec)');
ap_dis=find( ap_disc( est_ind:eet_ind ) > 0 );
if (isempty(ap_dis)) == 0
 disp(' ');
 disp([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 wrt_ap_dis=input('  Write Auto Pilot Disengage Time on plot ?  [<CR> Yes; <1> No]:
');
 if (isempty(wrt_ap_dis)) == 1
  gtext([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],2.5,['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax wrt_ap_dis
%
% Figure 2a - First da input
%
figure(2);clf;subplot(211);plot(time(pt_1:eet_ind),fas(pt_1:eet_ind));ax=axis;
plot(time(pt_1:eet_ind),fas(pt_1:eet_ind),'-b',[time(pt_1);time(eet_ind)],[10;10],'-k',...
   [time(pt_1);time(eet_ind)],[-10;-10],'-k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-
k');
grid on;zoom on;title('Configuration 6; First Definitive Aileron Input is when FAS > +-
10 lbs');std_hdr; ylabel('FAS (lbs)');
%
fst_da_pos=find( fas( est_ind:eet_ind ) >  10.0 );
fst_da_neg=find( fas( est_ind:eet_ind ) < -10.0 );
%
```

```
if (isempty(fst_da_pos)) == 0
  if (isempty(fst_da_neg)) == 0
    if fst_da_pos(1) < fst_da_neg(1),
      fst_da = fst_da_pos(1);
    elseif fst_da_neg(1) < fst_da_pos(1),
      fst_da = fst_da_neg(1);
    end
  else
    fst_da = fst_da_pos(1);
  end
elseif (isempty(fst_da_neg)) == 0
  fst_da = fst_da_neg(1);
else
  fst_da = [];
end
%
if (isempty(fst_da)) == 0
  disp(' ');
  disp([' First Definative da input = ',num2str(event_time(fst_da(1))),' seconds']);
  wrt_fst_da=input(' Write da Input Time on plot ? [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_da)) == 1
    gtext([' First Definative da Input = ',num2str(event_time(fst_da(1))),' seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_da fst_da_pos fst_da_neg
%
% Figure 2b - First dr input
%
subplot(212);plot(time(pt_1:eet_ind),frp(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),frp(pt_1:eet_ind),'-
b',[time(pt_1);time(eet_ind)],[10;10],'-k',...
          [time(pt_1);time(eet_ind)],[-10;-10],'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Rudder Input is when FRP > +-10 lbs');std_hdr;
ylabel('FRP (lbs)');
xlabel('Time (sec)');
%
fst_dr_pos=find( frp( est_ind:eet_ind ) >  10.0 );
fst_dr_neg=find( frp( est_ind:eet_ind ) < -10.0 );
%
if (isempty(fst_dr_pos)) == 0
```

```
 if (isempty(fst_dr_neg)) == 0
  if fst_dr_pos(1) < fst_dr_neg(1),
   fst_dr = fst_dr_pos(1);
  elseif fst_dr_neg(1) < fst_dr_pos(1),
   fst_dr = fst_dr_neg(1);
  end
 else
  fst_dr = fst_dr_pos(1);
 end
elseif (isempty(fst_dr_neg)) == 0
 fst_dr = fst_dr_neg(1);
else
 fst_dr = [];
end
%
if (isempty(fst_dr)) == 0
 disp(' ');
 disp([' First Definative dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
 wrt_fst_dr=input('  Write dr Input Time on plot ?  [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_dr)) == 1
  gtext([' First Definative dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_dr fst_dr_pos fst_dr_neg
%
% Figure 3a - First Definitive Throttle Split
%
figure(3);clf;subplot(211);plot(time(pt_1:eet_ind),thrust_l(pt_1:eet_ind),time(pt_1:eet_in
d),thrust_r(pt_1:eet_ind));ax=axis;
trim_thrust=thrust(est_ind)/2.0;
subplot(211);plot(time(pt_1:eet_ind),thrust_l(pt_1:eet_ind),'-
b',time(pt_1:eet_ind),thrust_r(pt_1:eet_ind),'-r',...
[time(pt_1);time(eet_ind)],[trim_thrust+300;trim_thrust+300],'-
k',[time(pt_1);time(eet_ind)],[trim_thrust-300;trim_thrust-300],'-k',...
[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 6; First Definitive Throttle Split: Thrust (lt-rt) > +-
300.0 lb');std_hdr; ylabel('Thrust Lt, Thrust Rt (lb)');
%
splt_thr=find(abs( thrust_l(est_ind:eet_ind) - thrust_r(est_ind:eet_ind) > 300.0));
%
if (isempty(splt_thr)) == 0
```

```
  disp(' ');
  disp([' First Definative Split Throttle = ',num2str(event_time(splt_thr(1))),' seconds']);
  wrt_fst_splt_thr=input(' Write Split Throttle Time on plot ? [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_splt_thr)) == 1
    gtext([' First Definative Split Throttle Input = ',num2str(event_time(splt_thr(1))),'
seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_splt_thr splt_thr trim_thrust
%
% Figure 3b - First Definitive Alpha Reducing Input
%
subplot(212);plot(time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),time(pt_1:eet_ind),de(pt_1:e
et_ind),time(pt_1:eet_ind),fes(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),de(pt_1:eet_ind),'-.r',...
            time(pt_1:eet_ind),fes(pt_1:eet_ind),'--
y',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
xlabel('Time (sec)');
grid on;zoom on;title('First Definitive Alpha Reducing Input (FES) ');std_hdr;
ylabel('Elev (deg), Alp (deg), Long Stk (lb)');legend('Alpha','Elevator','Stk Force',3);

alpha_est=alpha_cf(est_ind);
first_red_alp_ind_et=min(find( alpha_cf(est_ind:eet_ind) < alpha_est-5.0 )); % Event
Time

if (isempty(first_red_alp_ind_et)) == 0
  first_red_alp_ind_rt=min(find( time > event_time(first_red_alp_ind_et) )); % Record
Time
  first_de=find( fes(first_red_alp_ind_rt-(5.0/0.05):eet_ind) < -10.0 ); %Looking for nose
down de from 5.0 sec before reduced alpha
  event_time_3=time(first_red_alp_ind_rt-(5.0/0.05):eet_ind);
  if (isempty(first_de)) == 0
    disp(' ');
    disp([' First Definative Nose Down de Input = ',num2str(event_time_3(first_de(1))),'
seconds']);
    wrt_fst_de=input(' Write de Input Time on plot ? [<CR> Yes; <1> No]: ');
    if (isempty(wrt_fst_de)) == 1
      gtext([' First Definative Nose Down de Input = ',num2str(event_time_3(first_de(1))),'
seconds']);
    end
```

```
 end
end

if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_de first_red_alp_ind_et first_red_alp_ind_rt first_de event_time_3
%
% Figure 4a - Wheel Snatches, Aileron Effectiveness, Bank Angle
%
figure(4);clf;subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),time(pt_1:eet_ind),p(
pt_1:eet_ind),...
                    time(pt_1:eet_ind),fas(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),'--
r',time(pt_1:eet_ind),p(pt_1:eet_ind),'-k',...
            time(pt_1:eet_ind),fas(pt_1:eet_ind),'-
.b',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 6; Wheel Snatches, Aileron Effectiveness, Bank
Angle ');std_hdr; ylabel('Phi (deg), Pb (deg/sec)');
legend('Phi','Pb','FAS',3);
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax
%
% Figure 4b - Gamma, Theta, Alpha
%
subplot(212);plot(time(pt_1:eet_ind),gamma(pt_1:eet_ind),time(pt_1:eet_ind),theta(pt_1:
eet_ind),time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),gamma(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),theta(pt_1:eet_ind),'--b',time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),'-
.r',...
[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 6; Longitudinal Orientation ');
std_hdr; ylabel(' Gamma, Theta, Alpha (deg) ');xlabel('Time
(sec)');legend('Gamma','Theta','Alpha',3);
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax
```

```
%
% Figure 5a - First Definitive Throttle Input (Total Thrust)
%
figure(5);clf;subplot(211);plot(time(pt_1:eet_ind),thrust(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),thrust(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 6; First Definitive Throttle Input ');std_hdr;
ylabel('Total Thrust (Lbs)');
%
trim_thrust=thrust(est_ind);
fst_throttle=find(thrust(est_ind:eet_ind) > trim_thrust+200);
if (isempty(fst_throttle)) == 0
  disp(' ');
  disp([' First Definative Throttle Input = ',num2str(event_time(fst_throttle(1))),'
seconds']);
  wrt_fst_th=input(' Write First Throttle Input Time on plot ? [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_th)) == 1
    gtext([' First Definative Throttle Input = ',num2str(event_time(fst_throttle(1))),'
seconds']);
  end
end
%
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_th trim_thrust fst_throttle
%
% Figure 5b - Maximum Airspeed
%
subplot(212);plot(time(pt_1:eet_ind),vi(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),vi(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Maximum Airspeed ');std_hdr; ylabel('Velocity (KIAS)');
xlabel('Time (sec)');
%
max_air_spd=max(vi(est_ind:eet_ind));
if (isempty(max_air_spd)) == 0
  disp(' ');
  disp([' Maximum Airspeed = ',num2str(max_air_spd),' KIAS']);
  wrt_max_as=input(' Write Maximum Airspeed on plot ? [<CR> Yes; <1> No]: ');
  if (isempty(wrt_max_as)) == 1
    gtext([' Maximum Airspeed = ',num2str(max_air_spd),' KIAS']);
  end
end
```

```
%
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax max_air_spd wrt_max_as
%
% Figure 6a - Altitude Lost
%
event_alt=h_cf( est_ind:eet_ind );
min_alt=min(event_alt);
alt_lost=event_alt(1)-min_alt;

figure(6);clf;subplot(211);plot(time(pt_1:eet_ind),h_cf(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),h_cf(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 6; Altitude Lost During Event ');std_hdr;
ylabel('Altitude (Ft)');
disp(' ');
disp([' Altitude Lost = ',num2str(alt_lost),' Feet']);
wrt_alt_lst=input(' Write Altitude Lost on plot ? [<CR> Yes; <1> No]: ');
if (isempty(wrt_alt_lst)) == 1
 gtext([' Altitude Lost = ',num2str(alt_lost),' Feet']);
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear event_alt min_alt alt_lost ax wrt_alt_lst
%
% Figure 6b - Supporting Information
%
subplot(212);plot(time(pt_1:eet_ind),beta_cf(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),beta_cf(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Supporting Information');std_hdr; ylabel('Beta (deg)');
xlabel('Time (sec)');
%
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax
```

```
%
% Print orientation & Print option
%
for i=1:6,
 figure(i);orient('landscape');
end
%
disp(' ');
disp(' ');
prt = input('Print Figures 1-6 ?  [<CR> Yes; <1> No]: ');
if (isempty(prt)) == 1
 for i=1:6;figure(i);print;end;
end
```

17.8 DETROIT

```
% Determine event start time index, event end time index & event_time (sec)
%
st_1_ind=min(find( phi < -20.0 )) - (5.0/0.05);     % start time index for neg roll - 5
seconds
st_2_ind=min(find( phi >  20.0 )) - (5.0/0.05);     % start time index for pos roll - 5
seconds
%
if (isempty(st_1_ind)) == 0
 if (isempty(st_2_ind)) == 0
  if st_1_ind < st_2_ind,
   st_ind = st_1_ind;
   bank = -1.0;          % negative bank angle
  elseif st_2_ind < st_1_ind,
   st_ind = st_2_ind;
   bank =  1.0;          % positive bank angle
  end
 else
  st_ind = st_1_ind;
  bank = -1.0;           % negative bank angle
 end
elseif (isempty(st_2_ind)) == 0
 st_ind = st_2_ind;
 bank =  1.0;            % positive bank angle
else
 st_ind = 1;
 bank = 0.0;
end
%
eet_ind=length(time);                   % event end time (index)
%
```

```
t2=time(st_ind:eet_ind);                    % time frame of interest for determining event
start time
%
if bank == 1.0
 t2_ind=min(find(p(st_ind:eet_ind) > 5.0));
elseif bank == -1.0
 t2_ind=min(find(p(st_ind:eet_ind) < -5.0));
else
 t2_ind = 0;
end
%
est=(t2(t2_ind-(0.75/0.05)));               % event start time (sec) (Selected time - 0.75
sec)
est_ind=find(time==est);                    % event start time (index)
%
% Brute Force Event Start Time
%
if flight_number == 1510,
 if record_number == 8,
  est = 55.5;
  est_ind=min(find(time > est));
  eet_ind=min(find(time > 82.0));           % event end time (index)
 end
end
%
if flight_number == 1534,
 if record_number == 5,
  est = 61.8;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1542,
 if record_number == 8,
  est = 91.8;
  est_ind=min(find(time > est));
 end
end
%
if flight_number == 1568,
 if record_number == 10,
  est = 64.7;
  est_ind=min(find(time > est));
 end
end
%
```

```
if flight_number == 1576,
  if record_number == 8,
    est = 64.1;
    est_ind=min(find(time > est));
  end
end
%
event_time = time( est_ind:eet_ind );          % event time (sec)
pt_1=est_ind-(10.0/0.05);                     % time to start time history (sec)
clear st_1_ind st_2_ind st_ind t2 t2_ind est bank da_init
%
vss_dwn_md=find( sys_eng( est_ind:eet_ind ) < 1 );
if isempty(vss_dwn_md)
  vss_dm=0;
else
  vss_dm=1;
  time_vss_dm=event_time(vss_dwn_md(1));
end
%
% Figure 1a - Event start time & Bank Angle, Aileron Position and Lateral Stick
%
figure(1);clf;subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),time(pt_1:eet_ind),p(
pt_1:eet_ind),...
                         time(pt_1:eet_ind),fas(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),p(pt_1:eet_ind),'--r',...
             time(pt_1:eet_ind),fas(pt_1:eet_ind),'-
.b',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 8; Event Start Time');std_hdr; ylabel('Phi (deg), Pb,
(deg/sec), Fas (lb)');
legend('Phi','Roll Rate','Lat stk',4);
%
% look at entire record
%
subplot(212);plot(time,phi,'-k',time,p,'-r',time,fas,'-b');grid;zoom on;
        ylabel('Phi (deg), Pb, (deg/sec), Fas (lb)');legend('Phi','Roll Rate','Lat Stk',3);
%
if (isempty(est_ind)) == 0
  disp(' ');
  disp([' Event Start Time = ',num2str(time(est_ind)),' seconds']);
  wrt_est=input('  Write Event Start Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_est)) == 1
    gtext([' Event Start Time = ',num2str(time(est_ind)),' seconds']);
  end
end
if vss_dm == 1
```

```
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0], ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_est
%
% Figure 1b - Master disconnect
%
subplot(212);plot(time(pt_1:eet_ind),ap_eng(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),ap_eng(pt_1:eet_ind),'-
r',time(pt_1:eet_ind),ap_disc(pt_1:eet_ind),'-.b',...
           time(pt_1:eet_ind),sys_eng(pt_1:eet_ind),'--k',[time(est_ind);time(est_ind)],[-
1;3],'-k');
grid on;zoom on;axis([ax(1) ax(2) -1 3]);legend('Auto Pilot Engage','Auto Pilot
Disengage','VSS Engage');
title('Auto Pilot Engage (-r) & Disengage (-.b) & Sys-eng (--k)');ylabel('ap-eng, ap-disc,
sys-eng');
xlabel('Time (sec)');
ap_dis=find( ap_disc( est_ind:eet_ind ) > 0 );
if (isempty(ap_dis)) == 0
 disp(' ');
 disp([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 wrt_ap_dis=input('  Write Auto Pilot Disengage Time on plot ?  [<CR> Yes; <1> No]:
');
 if (isempty(wrt_ap_dis)) == 1
  gtext([' Auto Pilot Disengage Time = ',num2str(event_time(ap_dis(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],2.5,['VSS Downmode at ',num2str(time_vss_dm),'
seconds']);
end
clear ax wrt_ap_dis
%
% Figure 2a - First da input
%
figure(2);clf;subplot(211);plot(time(pt_1:eet_ind),fas(pt_1:eet_ind));ax=axis;
plot(time(pt_1:eet_ind),fas(pt_1:eet_ind),'-b',[time(pt_1);time(eet_ind)],[10;10],'-k',...
   [time(pt_1);time(eet_ind)],[-10;-10],'-k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-
k');
grid on;zoom on;title('Configuration 8; First Definitive Aileron Input is when FAS > +-
10 lbs');std_hdr; ylabel('FAS (lbs)');
%
fst_da_pos=find( fas( est_ind:eet_ind ) >  10.0 );
fst_da_neg=find( fas( est_ind:eet_ind ) < -10.0 );
```

```
%
if (isempty(fst_da_pos)) == 0
 if (isempty(fst_da_neg)) == 0
  if fst_da_pos(1) < fst_da_neg(1),
   fst_da = fst_da_pos(1);
  elseif fst_da_neg(1) < fst_da_pos(1),
   fst_da = fst_da_neg(1);
  end
 else
  fst_da = fst_da_pos(1);
 end
elseif (isempty(fst_da_neg)) == 0
 fst_da = fst_da_neg(1);
else
 fst_da = [];
end
%
if (isempty(fst_da)) == 0
 disp(' ');
 disp([' First Definative da input = ',num2str(event_time(fst_da(1))),' seconds']);
 wrt_fst_da=input(' Write da Input Time on plot ? [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_da)) == 1
  gtext([' First Definative da Input = ',num2str(event_time(fst_da(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_da fst_da_pos fst_da_neg
%
% Figure 2b - First dr input
%
subplot(212);plot(time(pt_1:eet_ind),frp(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),frp(pt_1:eet_ind),'-
b',[time(pt_1);time(eet_ind)],[10;10],'-k',...
          [time(pt_1);time(eet_ind)],[-10;-10],'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('First Definitive Rudder Input is when FRP > +-10 lbs');std_hdr;
ylabel('FRP (lbs)');
xlabel('Time (sec)');
%
fst_dr_pos=find( frp( est_ind:eet_ind ) > 10.0 );
fst_dr_neg=find( frp( est_ind:eet_ind ) < -10.0 );
%
```

```
if (isempty(fst_dr_pos)) == 0
 if (isempty(fst_dr_neg)) == 0
  if fst_dr_pos(1) < fst_dr_neg(1),
   fst_dr = fst_dr_pos(1);
  elseif fst_dr_neg(1) < fst_dr_pos(1),
   fst_dr = fst_dr_neg(1);
  end
 else
  fst_dr = fst_dr_pos(1);
 end
elseif (isempty(fst_dr_neg)) == 0
 fst_dr = fst_dr_neg(1);
else
 fst_dr = [];
end
%
if (isempty(fst_dr)) == 0
 disp(' ');
 disp([' First Definative dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
 wrt_fst_dr=input('  Write dr Input Time on plot ?  [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_dr)) == 1
  gtext([' First Definative dr Input = ',num2str(event_time(fst_dr(1))),' seconds']);
 end
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_dr fst_dr_pos fst_dr_neg
%
% Figure 3a - First Definitive Throttle Split
%
figure(3);clf;subplot(211);plot(time(pt_1:eet_ind),thrust_l(pt_1:eet_ind),time(pt_1:eet_in
d),thrust_r(pt_1:eet_ind));ax=axis;
trim_thrust=thrust(est_ind)/2.0;
subplot(211);plot(time(pt_1:eet_ind),thrust_l(pt_1:eet_ind),'-
b',time(pt_1:eet_ind),thrust_r(pt_1:eet_ind),'-r',...
[time(pt_1);time(eet_ind)],[trim_thrust+300;trim_thrust+300],'-
k',[time(pt_1);time(eet_ind)],[trim_thrust-300;trim_thrust-300],'-k',...
[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 8; First Definitive Throttle Split: Thrust (lt-rt) > +-
300.0 lb');std_hdr; ylabel('Thrust Lt, Thrust Rt (lb)');
%
splt_thr=find(abs( thrust_l(est_ind:eet_ind) - thrust_r(est_ind:eet_ind) > 300.0));
%
```

```
if (isempty(splt_thr)) == 0
  disp(' ');
  disp([' First Definative Split Throttle = ',num2str(event_time(splt_thr(1))),' seconds']);
  wrt_fst_splt_thr=input('  Write Split Throttle Time on plot ?  [<CR> Yes; <1> No]: ');
  if (isempty(wrt_fst_splt_thr)) == 1
    gtext([' First Definative Split Throttle Input = ',num2str(event_time(splt_thr(1))),'
seconds']);
  end
end
if vss_dm == 1
  ax=axis;
  text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_splt_thr splt_thr trim_thrust
%
% Figure 3b - First Definitive Alpha Reducing Input
%
subplot(212);plot(time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),time(pt_1:eet_ind),de(pt_1:e
et_ind),time(pt_1:eet_ind),fes(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),de(pt_1:eet_ind),'-.r',...
            time(pt_1:eet_ind),fes(pt_1:eet_ind),'--
y',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
xlabel('Time (sec)');
grid on;zoom on;title('First Definitive Alpha Reducing Input (FES) ');std_hdr;
ylabel('Elev (deg), Alp (deg), Long Stk (lb)');legend('Alpha','Elevator','Stk Force',1);

alpha_est=alpha_cf(est_ind);
first_red_alp_ind_et=min(find( alpha_cf(est_ind:eet_ind) < alpha_est-5.0 )); % Event
Time

if (isempty(first_red_alp_ind_et)) == 0
  first_red_alp_ind_rt=min(find( time > event_time(first_red_alp_ind_et) ));  % Record
Time
  first_de=find( fes(first_red_alp_ind_rt-(5.0/0.05):eet_ind) < -10.0 ); %Looking for nose
down de from 5.0 sec before reduced alpha
  event_time_3=time(first_red_alp_ind_rt-(5.0/0.05):eet_ind);
  if (isempty(first_de)) == 0
    disp(' ');
    disp([' First Definative Nose Down de Input = ',num2str(event_time_3(first_de(1))),'
seconds']);
    wrt_fst_de=input('  Write de Input Time on plot ?  [<CR> Yes; <1> No]: ');
    if (isempty(wrt_fst_de)) == 1
      gtext([' First Definative Nose Down de Input = ',num2str(event_time_3(first_de(1))),'
seconds']);
```

```
  end
 end
end

if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_de first_red_alp_ind_et first_red_alp_ind_rt first_de event_time_3
%
% Figure 4a - Wheel Snatches, Aileron Effectiveness, Bank Angle
%
figure(4);clf;subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),time(pt_1:eet_ind),p(
pt_1:eet_ind),...
                 time(pt_1:eet_ind),fas(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),phi(pt_1:eet_ind),'--
r',time(pt_1:eet_ind),p(pt_1:eet_ind),'-k',...
            time(pt_1:eet_ind),fas(pt_1:eet_ind),'-
.b',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 8; Wheel Snatches, Aileron Effectiveness, Bank
Angle ');std_hdr; ylabel('Phi (deg), Pb, (deg/sec), Fas (lb)');
legend('Phi','Roll Rate','Lat stk',1);
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax
%
% Figure 4b - Gamma, Theta, Alpha
%
subplot(212);plot(time(pt_1:eet_ind),gamma(pt_1:eet_ind),time(pt_1:eet_ind),theta(pt_1:
eet_ind),time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),gamma(pt_1:eet_ind),'-
k',time(pt_1:eet_ind),theta(pt_1:eet_ind),'--b',time(pt_1:eet_ind),alpha_cf(pt_1:eet_ind),'-
.r',...
[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 8; Longitudinal Orientation ');
std_hdr; ylabel(' Gamma, Theta, Alpha (deg) ');xlabel('Time
(sec)');legend('Gamma','Theta','Alpha',1);
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
```

```
clear ax
%
% Figure 5a - First Definitive Throttle Input (Total Thrust)
%
figure(5);clf;subplot(211);plot(time(pt_1:eet_ind),thrust(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),thrust(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 8; First Definitive Throttle Input ');std_hdr;
ylabel('Total Thrust (Lbs)');
%
trim_thrust=thrust(est_ind);
fst_throttle=find(thrust(est_ind:eet_ind) > trim_thrust+200);
if (isempty(fst_throttle)) == 0
 disp(' ');
 disp([' First Definative Throttle Input = ',num2str(event_time(fst_throttle(1))),'
seconds']);
 wrt_fst_th=input('  Write First Throttle Input Time on plot ?  [<CR> Yes; <1> No]: ');
 if (isempty(wrt_fst_th)) == 1
   gtext([' First Definative Throttle Input = ',num2str(event_time(fst_throttle(1))),'
seconds']);
 end
end
%
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax wrt_fst_th trim_thrust fst_throttle
%
% Figure 5b - Maximum Airspeed
%
subplot(212);plot(time(pt_1:eet_ind),vi(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),vi(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Maximum Airspeed ');std_hdr; ylabel('Velocity (KIAS)');
xlabel('Time (sec)');
%
max_air_spd=max(vi(est_ind:eet_ind));
if (isempty(max_air_spd)) == 0
 disp(' ');
 disp([' Maximum Airspeed = ',num2str(max_air_spd),' KIAS']);
 wrt_max_as=input('  Write Maximum Airspeed on plot ?  [<CR> Yes; <1> No]: ');
 if (isempty(wrt_max_as)) == 1
   gtext([' Maximum Airspeed = ',num2str(max_air_spd),' KIAS']);
 end
```

```
end
%
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear ax max_air_spd wrt_max_as
%
% Figure 6a - Altitude Lost
%
event_alt=h_cf( est_ind:eet_ind );
min_alt=min(event_alt);
alt_lost=event_alt(1)-min_alt;

figure(6);clf;subplot(211);plot(time(pt_1:eet_ind),h_cf(pt_1:eet_ind));ax=axis;
subplot(211);plot(time(pt_1:eet_ind),h_cf(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Configuration 8; Altitude Lost During Event ');std_hdr;
ylabel('Altitude (Ft)');
disp(' ');
disp([' Altitude Lost = ',num2str(alt_lost),' Feet']);
wrt_alt_lst=input(' Write Altitude Lost on plot ? [<CR> Yes; <1> No]: ');
if (isempty(wrt_alt_lst)) == 1
 gtext([' Altitude Lost = ',num2str(alt_lost),' Feet']);
end
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
clear event_alt min_alt alt_lost ax wrt_alt_lst
%
% Figure 6b - Supporting Information
%
subplot(212);plot(time(pt_1:eet_ind),beta_cf(pt_1:eet_ind));ax=axis;
subplot(212);plot(time(pt_1:eet_ind),beta_cf(pt_1:eet_ind),'-
k',[time(est_ind);time(est_ind)],[ax(3);ax(4)],'-k');
grid on;zoom on;title('Supporting Information');std_hdr; ylabel('Beta (deg)');
xlabel('Time (sec)');
%
if vss_dm == 1
 ax=axis;
 text(ax(1)+[( ax(2)-ax(1) )/15.0],ax(4)-[( ax(4)-ax(3) )/8.0],['VSS Downmode at
',num2str(time_vss_dm),' seconds']);
end
```

```
clear ax
%
% Print orientation & Print option
%
for i=1:6,
 figure(i);orient('landscape');
end
%
disp(' ');
disp(' ');
prt = input('Print Figures 1-6 ? [<CR> Yes; <1> No]: ');
if (isempty(prt)) == 1
 for i=1:6;figure(i);print;end;
end
```

18. APPENDIX K – LIST OF AIRCRAFT FLOWN BY EVALUATION PILOTS

Group	List of Aircraft Flown
No Aero/No Upset	BA 3100, BA 4100, C-206, BE 95
No Aero/No Upset	HS-125, BE-40, A320, A319
No Aero/No Upset	Ba-31, C-402c, BE-55, PA-28R, PA-28, PA-44, C-177RG, C-182, C-172RG, C-172, T-34, C-152, C-150, M020J, C-303
No Aero/No Upset	CE-500, BE 20, BE 10, BE 90, BE 58, DC-9, CE-560xl
No Aero/No Upset	DC-9, LR-25, LR-35, C-310, PA-31, C-172, C-182, C-152, C-150, Piper Colt, PA-34
No Aero/No Upset	DC-9, DC-8, B747, MD-80, Learjet, Citation II, CE-208, Duchess, Aztec, SE piston Cessnas; 150, 152,172,187,206,207, BE-35, PA-28
No Aero/No Upset	DHC-6, DHC-300, DC-9, BE-1900, SF-340
No Aero/No Upset	PA-28; 181-161-200R-201R, M20, PA31-310, CE340, CE421, BAE-4100, CC-65, PA34-200, CE-152, TB-9, TB-20
No Aero/Upset	C-150, C-52, C-172, C-195, C-206, C-310, C-401, C-425, C-441, BE-55, BE-58, BE-20, BE-9T, Dazo, 11AC, PA- 28, PA-32, PA-34, SF-34
No Aero/Upset	SAAB 340B, CE-500/5001, BE-55, BE-58, C-401, C-172, C-182R6, C-150, C-195
No Aero/Upset	C-172, A-36, BE-76, BE-90, PE-12, ATR-42/72, PA-28
No Aero/Upset	SF-340, Single Engine Props, Twin Props
No Aero/Upset	BA-32, (Jetstream) BA31
No Aero/Upset	A-320, A-319, DC9-30, Piper singles, Cessna singles, Beechcraft singles, Pitts, Z Citabria, Citation II, Beech Duchess
No Aero/Upset	SF-340B, BE-76, C-152/172
No Aero/Upset	C-152, C-172, C-182, J-3, PA-11, PA-23, BE-1900, EMB120, CL65, B-727
Aero/No Upset	DHCS, NA-265, LR24, BE-90, PA-34, PA-23, PA-44
Aero/No Upset	Cessna, Pipers, Beechcraft, Bagons, F-90, MD-80, Experimentals, RU-4, Decathlons
Aero/No Upset	Cessna, Piper, Beech, Beech 1900, Airbus A320
Aero/No Upset	ERJ-145, ERJ-135, BE-58, Piper Twins, Piper Single, C-310, Cessna Singles, Mooney Singles, Aeroncas, Decathlons
Aero/No Upset	J-32, J-41, 737, DC-9, C-310, Single engine Cessna, gliders
Aero/No Upset	LR-25, LR-35, B-727, B737
Aero/No Upset	Pawnee, Apache Aztec, Chieftain, Twin otter, Dash-8, C-150, PA-32, Super Cub, Fairchild F-24, Great lakes, C-172, C-180, C-182, C-185
Aero/No Upset	All Single Cessna, C-340, C-441, Paye, Be-90, Emb-120, CE-500, CRJ-65, Pitts S2A, Pitts S2B
Aero/Upset	C-152, C-172, C-206, PA-28, PA-31, Emb-120, CL-65
Aero/Upset	E-120, Brasilia, Cessna 172, BE-76, Duchess, F-33A, Beechcraft Bonanza, 8KCAB, Decathlon, Super Decathlon
Aero/Upset	AT-72, AT-42, PA-34, PA-32
Aero/Upset	CL-65, Emb-120
Aero/Upset	C-150/152, C-172, Pa-28, PA-44, C-500/550, CL-65
Aero/Upset	CL-65, Emb-110, C-182, BE-58, BE-72, Decathlon, Citabria, C-172, C-152, C-150, PA-23, PA-24
Aero/Upset	C-152, C-172, C-172RG, Mooney 201, Pa-44, Mudry Cap10, Grab G-109, DA-20, EMB-120
Aero/Upset	Cessna, Twin Cessna, Beechcraft, Piper, Grumman Extra 300S/L, Pitts, Decathlon
In-flight	CL-65, Emb-120, Br-1900, Be-90, Be-58, C-414
In-flight	DC-9/10, DC-9/30, PA-28, J-3, PA-16, G-44, BE-1900D, PA-31/350, C-340A, C-152/172/182/170/140
In-flight	Cessna 140/150/152/170/172/185/310/337/340, Piper J-3, Supercub,

Group	List of Aircraft Flown
	Cherokee 140, Warrior, Arrow, Aztec, PA-30 Twin Comanche, Beechcraft Bonanza, Baron, Kingair 200, Starship, Beechjet 400A, Grumman Tiger, Ballonca Viking, EMB-120
In-flight	CR-7, LR-55/25/24, CE-525/550, C150/152/172, PA-32/34, BE-76
In-flight	Cessna Singles/Multi piston, BE-1900/D, Piper multiple singles piston, BAE-4100, SA-226 Merlin IIIb, B-737
In-flight	L-1011, B-737, Various light A/C
In-flight	CL-65, Canada Regional Jet, Beech 1700, C-172, C-72RG/482/210/310, DHL-6, PA-44 Seminole, BE-76 Duchess, Piper Arrow
In-flight	C-150/172/152/182, PA-28/160, PA-23/160, E-120

19. APPENDIX L – TRANSCRIPTS OF EVALUATION SCENARIOS

19.1 NO AERO/NO UPSET GROUP

19.1.1 Subject 1

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(Seconds)				
0:00:00			Script Detroit			
0:00:32	0:00:00	0				Data Record 5
0:00:55	0:00:23	23	ATC call to Slow down			
0:01:45	0:01:13	73			Max Power!	
0:01:46	0:01:14	74			Max Power set!	
0:02:01	0:01:29	89			All right I have power.	
0:02:02	0:01:30	90		All right, I'll take control.		
0:02:03	0:01:31	91			You have the aircraft?	
0:02:04	0:01:32	92		I have control.		
0:02:05	0:01:33	93				VSS Disconnect
0:02:50			Script Roselawn			
0:02:23	0:00:00	0				Data Record 6
0:03:03	0:00:40	40	ATC Speed			
0:04:11	0:01:48	108	ATC call to Turn			
0:04:12	0:01:49	109			Ah!	
0:04:15	0:01:52	112			Uh, we have a right control malfunction! Tell him to hold on it! Stand by Veridian one zero two we have a problem.	
0:04:22	0:01:59	119			We will go max power.	
0:04:27	0:02:04	124				VSS Disconnect
0:04:28	0:02:05	125		I have control.		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:06:37			Script Toledo			
0:07:54	0:00:00	0				Data Record 7
0:08:06	0:00:12	12	ATC Contact Departure			
0:08:26	0:00:32	32	ATC Climb			
0:08:41	0:00:47	47	ATC call to Turn			
0:08:49	0:00:55	55			Watch the bank angle!	
0:08:50	0:00:56	56		I got it.		
0:08:53	0:00:59	59			Bank angle!	
0:08:54	0:01:00	60				VSS Disconnect
0:08:56	0:01:02	62		I have control.		
0:10:31			Script Pittsburgh			
0:11:13	0:00:00	0				Data Record 8
0:11:36	0:00:23	23	ATC call to Turn			
0:12:33	0:01:20	80		Ok, I have control		VSS Disconnect
0:14:03			Script Shemya			
0:14:40	0:00:00	0				Data Record 9
0:15:16	0:00:36	36				VSS Disconnect
0:15:19	0:00:39	39		Ok, I have control.		
0:18:20			Script Charlotte			
0:19:43	0:00:00	0				Data Record 11
0:19:58	0:00:15	15	ATC call to Turn			
0:20:39	0:00:56	56	ATC call to Turn			
0:22:29	0:02:46	166	ATC Switch to			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
			Tower			
0:22:42	0:02:59	179	Clearance to Land			
0:24:43	0:05:00	300			We go on the bends.	
0:23:45	0:04:02	242			Max power!	
0:24:28	0:04:45	285			Awe ya; we have a windshear, max power set.	
0:25:06	0:05:23	323		Ok, I'll take control.		
0:25:07	0:05:24	324				VSS Disconnect
0:25:49			Script Nagoya			
0:26:42	0:00:00	0				Data Record 12
0:26:55	0:00:13	13	ATC call to Turn			
0:27:35	0:00:53	53	ATC call to Turn			
0:27:52	0:01:10	70	ATC Advisory			
0:30:09	0:03:27	207	ATC Switch to Tower			
0:30:33	0:03:51	231	ATC Clearance to Land			
0:31:18	0:04:36	276			We are going missed approach.	
0:31:20	0:04:38	278			Max Power set	
0:31:27	0:04:45	285		Watch your air speed; watch your airspeed.		
0:31:31	0:04:49	289			Perfect	
0:31:32	0:04:50	290		I have control.		VSS Disconnect
0:32:52			Script Birmingham			
0:33:26	0:00:00	0				Data Record 13

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:33:28	0:00:02	2	ATC call to Turn			
0:34:13	0:00:47	47	ATC call to Turn			
0:35:44	0:02:18	138			Lets go max power!	
0:35:57	0:02:31	151			I want to reduce the power here a little bit.	
0:35:58	0:02:32	152		Reduce the power.		
0:36:00	0:02:34	154			That's kind of good.	
0:36:05	0:02:39	159			Max power back up!	
0:36:06	0:02:40	160		Max power backup.		
0:36:07	0:02:41	161				VSS Disconnect
0:36:08	0:02:42	162		Ok, I have control.		
0:36:17	0:02:51	171		Wee!	(Laughs)	
0:30:58	0:00:00	0	Surprise Pittsburgh			Data Record 14
0:33:06	0:02:08	128				VSS Disconnect
0:33:07	0:02:09	129		Ok, I have control.		

19.1.2 Subject 2

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(Seconds)				
0:00:00			Script Birmingham			
0:00:33	0:00:00	0				Data Record 5
0:00:49	0:00:16	16	ATC call to Turn			
0:01:21	0:00:48	48	ATC call to Turn			
0:02:39	0:02:06	126				VSS

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
						Disconnect
0:02:40	0:02:07	127		Ok, I have control.	You have control.	
0:03:52			Script Nagoya			
0:04:46	0:00:00	0				Data Record 6
0:04:54	0:00:08	8	ATC call to Turn			
0:05:29	0:00:43	43	ATC call to Turn			
0:05:48	0:01:02	62	ATC Advisory			
0:07:08	0:02:22	142	ATC Switch to Tower			
0:07:23	0:02:37	157	ATC Clearance to Land			
0:08:50	0:04:04	244		Watch your going high on the glide slope.		
0:08:51	0:04:05	245			All right, going around.	
0:08:52	0:04:06	246		Ok, going around.		
0:08:53	0:04:07	247			Emergency Trim.	
0:08:54	0:04:08	248		And emergency trim.		
0:09:07	0:04:21	261		Ok, I'll take it. I have control.		
0:09:08	0:04:22	262				VSS Disconnect
0:09:16	0:04:30	270			I didn't over attempt anything did I?	
0:09:17	0:04:31	271		Nope		
0:09:18	0:04:32	272			I realized after I turned it off I pushed a little hard.	
0:09:19	0:04:33	273		At this altitude in a Lear jet, you're not going to over temp anything.		
0:09:20	0:04:34	274			That's good to know.	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:09:58			Script Detroit			
0:11:19	0:00:00	0				Data Record 7
0:11:43	0:00:24	24	ATC call to Slow down			
0:12:26	0:01:07	67		Ok I have control.		VSS Disconnect
0:12:30	0:01:11	71		That was a fun one huh.	Ya, (laughs).	
0:12:33	0:01:14	74			I thought I had it once then I'd come off again.	
0:13:54			Script Shemya			
0:14:19	0:00:00	0				Data Record 8
0:14:47	0:00:28	28			Wuh…	VSS Disconnect
0:14:48	0:00:29	29		Ok, I have control		
0:14:50	0:00:31	31			All right, you have control.	
0:18:13			Script Toledo			
0:18:57	0:00:00	0				Data Record 10
0:19:06	0:00:09	9	ATC Contact Departure			
0:19:20	0:00:23	23	ATC Climb			
0:19:43	0:00:46	46	ATC call to Turn			
0:19:50	0:00:53	53			Bank angle, watch it, watch it, I've got control.	
0:19:53	0:00:56	56		You've got it?	I've got it.	
0:20:04	0:01:07	67		You've got max power.		
0:20:12	0:01:15	75		Ok, I'll take control		
0:20:13	0:01:16	76				VSS Disconnect

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:20:57			Script Pittsburgh			
0:21:22	0:00:00	0				Data Record 11
0:21:57	0:00:35	35	ATC call to Turn			
0:22:39	0:01:17	77				VSS Disconnect
0:22:40	0:01:18	78		Ok, I have control.		
0:22:41	0:01:19	79			You have control.	
0:24:03			Script Roselawn			
0:24:35	0:00:00	0				Data Record 12
0:25:00	0:00:25	25	ATC Speed			
0:25:22	0:00:47	47			(Snap)	
0:25:24	0:00:49	49		Oh, I have control,		VSS Disconnect
0:25:26	0:00:51	51	ok	I think we broke something in the column. I think we broke the cables.		

19.1.3 Subject 3

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(Seconds)				
0:00:00			Script Toledo			
0:00:43	0:00:00	0				Data Record 5
0:00:55	0:00:12	12	ATC Contact Departure			
0:01:15	0:00:32	32	ATC Climb			
0:01:33	0:00:50	50	ATC call to Turn			
0:01:39	0:00:56	56			Watch your climb. Watch your climb!	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:01:41	0:00:58	58			I got, I got…	
0:01:42	0:00:59	59		You have the airplane?		
0:01:43	0:01:00	60			I have the airplane!	VSS Disconnect
0:01:44	0:01:01	61		That's fine, I have it now.		
0:01:45	0:01:02	62		Very good.		
0:03:19			Script Charlotte			
0:03:42	0:00:00	0				Data Record 6
0:03:51	0:00:09	9	ATC call to Turn			
0:05:38	0:01:56	116	ATC call to Turn			
0:07:07	0:03:25	205	ATC Switch to Land			
0:07:26	0:03:44	224	ATC Clearance to Land			
0:09:24	0:05:42	342			Go-Around Thrust!	
0:09:26	0:05:44	344		Ok, we have thrust.		
0:09:30	0:05:48	348			Ah missed approach. Flaps…Positive Rate. Gear up.	
0:09:32	0:05:50	350		Gear coming up.		
0:09:34	0:05:52	352			Flaps 20	
0:09:36	0:05:54	354		Flaps set.		
0:09:39	0:05:57	357			Is this…this is the stick shaker isn't it.	
0:09:41	0:05:59	359		Yup.		
0:09:42	0:06:00	360			Ok, Max thrust, Firewall power.	
0:09:43	0:06:01	361		Its is, It is	OK,	
0:09:48	0:06:06	366		Ok, very good.		
0:09:49	0:06:07	367		Ok I have the airplane.		
0:09:50	0:06:08	368		That's the end of that scenario.		VSS Disconnect

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:10:37			Script Detroit			
0:11:20	0:00:00	0				Data Record 7
0:11:56	0:00:36	36	ATC call to Slow down			
0:12:22	0:01:02	62			All right, bring the flaps up. Bring the flaps up!	
0:12:23	0:01:03	63		Flaps coming up.		
0:12:26	0:01:06	66			Ok	
0:12:31	0:01:11	71			All right Max power.	
0:12:33	0:01:13	73		Max power set.		
0:12:37	0:01:17	77			All right, now a solution. (under breath)	
0:12:45	0:01:25	85		Ok, very good. I have the airplane.		
0:12:46	0:01:26	86				VSS Disconnect
0:12:49	0:01:29	89		Scenario's over.		
0:14:12			Script Pittsburgh			
0:14:38	0:00:00	0				Data Record 8
0:14:52	0:00:14	14	ATC call to Turn			
0:15:52	0:01:14	74			All right! (Argh)	
0:15:53	0:01:15	75			Lose power!	
0:15:54	0:01:16	76		Powers off.		
0:15:56	0:01:18	78			All right, bring the ah..........	
0:16:00	0:01:22	82			Argh...You gotta try your control!	
0:16:03	0:01:25	85		I have no control.		ok
0:16:04	0:01:26	86				VSS Disconnect
0:16:05	0:01:27	87		I have the airplane.		
0:16:07	0:01:29	89		Very good.		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:16:08	0:01:30	90			That step would have been going in that direction. (laughs)	
0:17:55			Script Birmingham			
0:18:22	0:00:00	0				Data Record 9
0:18:36	0:00:14	14	ATC call to Turn			
0:19:19	0:00:57	57	ATC call to Turn			
0:20:41	0:02:19	139			Localizers are on.	
0:20:52	0:02:30	150			Alright, let's ah…	
0:20:55	0:02:33	153			Disconnect the ....Pitch trip, pitch trip!	
0:20:58	0:02:36	156				VSS Disconnect
0:20:59	0:02:37	157		Ok, I have the airplane.		
0:21:55			Script Roselawn			
0:22:24	0:00:00	0				Data Record 10
0:22:56	0:00:32	32	ATC Speed			
0:23:25	0:01:01	61			All right I'll tell you what. Bring the flaps back down!	
0:23:27	0:01:03	63		Flaps back down.		
0:23:33	0:01:09	69			Flaps back down at 20	
0:23:34	0:01:10	70		They are.		
0:23:38	0:01:14	74			ARGH!!	
0:23:44	0:01:20	80		Ok, I have the airplane.		
0:23:45	0:01:21	81				VSS Disconnect
0:25:08			Script Shemya			
0:25:24	0:00:00	0				Data

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
						Record 11
0:25:46	0:00:22	22			Does this thing have auto throttles also?	
0:25:47	0:00:23	23		No I guess not.		
0:25:50	0:00:26	26			Ah, Lets see what's going on, we are in a slow decent.	
0:26:00	0:00:36	36			Autopilot's disengaged, there we go.	
0:26:26	0:01:02	62		Very good, see how sensitive this is.	Yea	
0:26:32	0:01:08	68		Try to pitch up 5 degrees and stop it there.		
0:26:35	0:01:11	71		Pitch down.		
0:26:37	0:01:13	73		We've ended the experiment; I'm just showing you something.		
0:27:33			Script Nagoya			
0:27:58	0:00:00	0				Data Record 12
0:28:10	0:00:12	12	ATC call to Turn			
0:28:44	0:00:46	46	ATC call to Turn			
0:30:23	0:02:25	145	ATC Switch to Tower			
0:30:40	0:02:42	162	ATC Clearance to Land			
0:32:26	0:04:28	268			Disconnect the pitch trim.	
0:32:27	0:04:29	269		Ok		
0:32:28	0:04:30	270			Stand by pitch trim.	
0:32:29	0:04:31	271		You got it?		
0:32:31	0:04:33	273			All right trip down.	
0:32:33	0:04:35	275			And lets go miss.	
0:32:34	0:04:36	276			Max Power.	
0:32:36	0:04:38	278		Max power set.		
0:32:37	0:04:39	279			Max Thrust.	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:32:40	0:04:42	282			Flaps 20	
0:32:41	0:04:43	283		Flaps set.		
0:32:42	0:04:44	284			Positive rate, gear up.	
0:32:43	0:04:45	285		Gear up.		
0:32:45	0:04:47	287			All right, were in stick shaker.	
0:32:47	0:04:49	289			Go firewall.	
0:32:49	0:04:51	291		Firewall power. You got it?	All right.	
0:32:53	0:04:55	295		All right, I'll take the airplane.		
0:32:55	0:04:57	297		Very good, scenario's over.		VSS Disconnect
0:33:16	0:00:00	0	Surprise Pittsburgh			Data Record 13
0:34:31	0:01:15	75			Disconnect the Rudder, Rudder!	
				Ok	Disconnect the Rudder	
0:34:34	0:01:18	78		Rudder disconnected.	Ok, and rudder trim that.	
0:34:37	0:01:21	81		Rudder Trim.		
0:34:38	0:01:22	82			And (argh), power off.	
0:34:40	0:01:24	84		Powers off.		
0:34:41	0:01:25	85		Alright I have the airplane		
0:34:42	0:01:26	86				VSS Disconnect

19.1.4 Subject 4

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(Seconds)				
0:00:00			Script Roselawn			
0:00:29	0:00:00	0				Data Record 6

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:01:04	0:00:35	35	ATC Speed			
0:01:52	0:01:23	83	ATC call to Turn			
0:02:52	0:02:23	143	ATC call to Turn			
0:03:01	0:02:32	152			Arrgh!!!	
0:03:04	0:02:35	155			Max power!	
0:03:05	0:02:36	156		Max power set		
0:03:11	0:02:42	162			Ok, I'm going to need to.........we're going to climb out of this!	
0:03:12	0:02:43	163		Ok, got power, don't worry, I got the power set for you. All right.		
0:03:25	0:02:56	176		I have the airplane.		
0:03:26	0:02:57	177				VSS Disconnect
0:04:31			Script Charlotte			
0:04:57	0:00:00	0				Data Record 7
0:05:08	0:00:11	11	ATC call to Turn			
0:05:46	0:00:49	49	ATC call to Turn			
0:07:34	0:02:37	157	ATC Switch to Tower			
0:07:51	0:02:54	174	ATC Clearance to Land			
0:08:11	0:03:14	194			Something screwy going wrong here!	
0:08:15	0:03:18	198			I do feel the turbulence.	
0:08:18	0:03:21	201			Ok, gear down please.	
0:08:20	0:03:23	203		Ok, gear coming down.		
0:08:25	0:03:28	208			Ask him what the winds were again on the ground.	
0:08:28	0:03:31	211		Three green, Denver, say again what your winds are.		
0:08:41	0:03:44	224			Landing flaps.	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:08:42	0:03:45	225		Landing flaps set.		
0:09:05	0:04:08	248			Getting quite an increase in airspeed here.	
0:09:44	0:04:47	287			Ok, I'm pulling the plug and going around.	
0:09:45	0:04:48	288		Ok		
0:09:47	0:04:50	290			Ok, uh, flaps up, flaps 20.	
0:09:51	0:04:54	294			Also landing gear up.	
0:10:01	0:05:04	304		Ok	And tell Denver we are on the miss.	
0:10:02	0:05:05	305		I have the airplane.		
0:10:03	0:05:06	306				VSS Disconnect
0:11:27			Script Birmingham			
0:12:00	0:00:00	0				Data Record 8
0:12:15	0:00:15	15	ATC call to Turn			
0:12:51	0:00:51	51	ATC call to Turn			
0:13:59	0:01:59	119			Wuh!!	
0:14:05	0:02:05	125			Ask Denver if we are following any traffic!	
0:14:15	0:02:15	135			It's a full yoke forward.	
0:14:27	0:02:27	147		All right, I'll take it.		
0:14:28	0:02:28	148				VSS Disconnect
0:15:47			Script Nagoya			
0:16:18	0:00:00	0				Data Record 9
0:16:35	0:00:17	17	ATC call to Turn			
0:17:09	0:00:51	51	ATC call to Turn			
0:18:21	0:02:03	123	ATC Advisory			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:19:07	0:02:49	169	ATC Switch to Tower			
0:19:21	0:03:03	183	ATC Clearance to Land			
0:20:58	0:04:40	280			Just about full forward yoke here.	
0:21:03	0:04:45	285			Ok, I'm going to add thrust.	
0:21:07	0:04:49	289			I'm at forward limits.	
0:21:08	0:04:50	290			Can you help me push forward on the stick?	
0:21:09	0:04:51	291			Tell Denver we are going around.	
0:21:14	0:04:56	296		I'm helping, I'm helping	Full thrust.	
0:21:16	0:04:58	298		Full thrust set.		
0:21:18	0:05:00	300			Flaps 20	
0:21:19	0:05:01	301		Flaps coming up		
0:21:20	0:05:02	302			Gear up.	
0:21:21	0:05:03	303		Gear coming up.		
0:21:22	0:05:04	304			Holy Crud!!	VSS Disconnect
0:21:23	0:05:05	305		Ok, I have the airplane.		
0:21:25	0:05:07	307			Ok, you've got it.	
0:22:42			Script Detroit			
0:23:24			Repeat Script			
0:23:44	0:00:00	0				Data Record 10
0:24:18	0:00:34	34	ATC call to Slow down			
0:24:50	0:01:06	66			Argh!	
0:24:56	0:01:12	72			Max power!	
0:25:00	0:01:16	76		ok	Ok we've got power?	
0:25:03	0:01:19	79		ok	Help me with the stick!!!!!! (Argh) Go right!!!	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:25:10	0:01:26	86				VSS Disconnect
0:25:11	0:01:27	87		Ok, I have the airplane.		
0:25:12	0:01:28	88			Ok, you have the airplane	
0:25:42	0:01:58	118			I need.......................a little bit of a breather.	
0:25:47	0:02:03	123		Ok, that's fine, just fly straight for a little bit.		
0:25:48	0:02:04	124			You have enough air in here?	
0:26:17	0:02:33	153			I need to take this off for a second.	
0:26:19	0:02:35	155		Sure.		
0:28:29	0:04:45	285			Ok, I'm back with you.	
0:28:53			Script Shemya			
0:29:11	0:00:00	0				Data Record 11
0:29:48	0:00:37	37			What's this stick doing?	
0:29:49	0:00:38	38			Ok, I've got it. Autopilot off.	
0:29:50	0:00:39	39		You've got it.		
0:29:53	0:00:42	42			Eeeeeesh!	
0:29:54	0:00:43	43				VSS Disconnect
0:29:55	0:00:44	44		Ok, I've got it.		
0:29:56	0:00:45	45			You've got it.	
0:31:02	0:01:51	111			I'm going to take my headset off for a second.	
0:31:03	0:01:52	112		Sure go ahead. I'll slow down a little bit and you can rest.		
0:33:10	0:03:59	239			Ok, I'm ready.	
0:33:15			Script Toledo			
0:33:53	0:00:00	0				Data

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
						Record 13
0:34:06	0:00:13	13	ATC Contact Departure			
0:34:18	0:00:25	25	ATC Climb			
0:34:26	0:00:33	33	ATC Climb (repeat)			
0:34:40	0:00:47	47	ATC call to Turn			
0:34:50	0:00:57	57			Over banking!	
0:34:51	0:00:58	58		You've got it.	IIIIII've got it!!! (Argh)	
0:35:03	0:01:10	70			Ok, what's the status; did we lose an engine or something?	
0:35:07	0:01:14	74		No, I don't know what happened!		
0:35:11	0:01:18	78		Ok I'll let go.	Ok, I'm holding left aileron. Over Pitch	
0:35:14	0:01:21	81		I've got the airplane.		
0:35:15	0:01:22	82				VSS Disconnect
0:35:28	0:01:35	95			(Head set is removed)	
0:36:23	0:02:30	150	Ok, ...Here's your introduction.			
0:36:25	0:02:32	152			Not yet, head sets off.	
0:39:00	0:05:07	307			Ok (head set on) I'm back with you.	
0:39:05			Script Pittsburgh			
0:39:33						Data Record 14
0:39:53				Speed failure restart	(Takes break)	
0:41:26					Ok, I'm ready	
0:42:00			Script Reread			
0:42:30					I need to take another minute here.	
0:42:32			Sure, no problem.			
0:44:51					Ok, I'm back with you now.	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:44:48			Script 2nd reread			
0:45:14	0:00:00	0				Data Record 15
0:45:26	0:00:12	12	ATC call to Turn			
0:46:06	0:00:52	52			Argh. We have a problem!	
0:46:07	0:00:53	53			Oh...My......	
0:46:09	0:00:55	55			Help me out on the rudder!!	
0:46:12	0:00:58	58				VSS Disconnect
0:46:14	0:01:00	60		I've got the airplane.		
0:46:23	0:01:09	69			(Heavy long breathing)	
0:47:13	0:01:59	119			(Grabs vomit bag)	
0:51:29	0:06:15	375		Hey, thanks for hanging in there.		
0:51:30	0:06:16	376			(Laughs) geese that was not an easy one.	

19.1.5 Subject 5

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(seconds)				
0:00:00			Script Roselawn			
0:01:02			ATC Speed			
0:01:21	0:00:00	0				Data Record 5
0:01:28	0:00:07	7			Turn the power up for me please so we can hit 180 KIAS	
0:01:32	0:00:11	11			Ok, Oh.	
0:01:38	0:00:17	17			Ok, we are stalling.	
0:01:42	0:00:21	21			We are not in a shaker or	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
					anything?	
0:01:46	0:00:25	25			We've got a… what's going on?	
0:01:47	0:00:26	26	ATC call to Turn			
0:02:12	0:00:51	51			It seems like the airplane is trying to roll over on the right on me.	
0:02:40	0:01:19	79			We are in an ice storm. Let's blow the boots please.	
0:02:43	0:01:22	82			Lets get all the ice and snow off please.	
0:02:47	0:01:26	86			Ok	
0:02:49	0:01:28	88			Are you ready to knock it off?	
0:02:53	0:01:32	92			Are you going to take it?	VSS Disconnect
0:02:54	0:01:33	93		I have control.		
0:03:40			Script Birmingham			
0:05:34			Repeat Script			
0:05:57	0:00:00	0				Data Record 6
0:06:30	0:00:33	33	ATC call to Turn			
0:07:38	0:01:41	101	ATC call to Turn			
0:09:11	0:03:14	194			There's a pretty good shear out here.	
0:09:22	0:03:25	205			OOOOOOOKKK!	
0:09:23	0:03:26	206				VSS Disconnect
0:09:24	0:03:27	207		I have control.		
0:10:34			Script Pittsburgh			
0:11:25	0:00:00	0				Data

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
						Record 7
0:11:43	0:00:18	18	ATC call to Turn			
0:12:46	0:01:21	81			OHHH Looks like we have a rudder hard over.	
0:13:02	0:01:37	97		Ok, I'm going to take it.		
0:13:03	0:01:38	98				VSS Disconnect
0:13:17	0:01:52	112		That's a fun one huh.		
0:13:18	0:01:53	113			Ya, I liked that one.	
0:14:03			Script Detroit			
0:14:30	0:00:00	0				Data Record 8
0:15:05	0:00:35	35	ATC Speed			
0:15:56	0:01:26	86				VSS Disconnect
0:15:57	0:01:27	87		Ok, I have control.		
0:16:46			Script Charlotte			
0:17:25	0:00:00	0				Data Record 9
0:17:38	0:00:13	13	ATC call to Turn			
0:18:28	0:01:03	63	ATC call to Turn			
0:20:25	0:03:00	180	ATC Switch to Tower			
0:20:43	0:03:18	198	ATC Clearance to Land			
0:22:58	0:05:33	333			Ok, We have a windshear, a windshear!	
0:23:01	0:05:36	336			Look at that airspeed! We have a windshear!	
0:23:04	0:05:39	339			Max power!	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:23:05	0:05:40	340		Ok, maxpower.		
0:23:07	0:05:42	342			Max power set.	
0:23:15	0:05:50	350			Ok, we have a positive right.	
0:23:19	0:05:54	354			Keep in this configuration.	
0:23:20	0:05:55	355		OK		
0:23:22	0:05:57	357		Hay, watch your speed there its getting really slow.		
0:23:34	0:06:09	369		Ok, let's knock it off.		
0:23:36	0:06:11	371				VSS Disconnect
0:23:37	0:06:12	372		And I have control, good job.		
0:24:21			Script Toledo			
0:25:17	0:00:00	0				Data Record 10
0:25:45	0:00:28	28	ATC Contact Departure			
0:25:58	0:00:41	41	ATC Climb			
0:26:06	0:00:49	49	ATC call to Turn			
0:26:15	0:00:58	58			Ok and your descending!	
0:26:17	0:01:00	60			You're over banking!	
0:26:18	0:01:01	61		You got it?		
0:26:19	0:01:02	62				VSS Disconnect
0:26:20	0:01:03	63		I have control.		
0:26:21	0:01:04	64			You have control.	
0:26:24	0:01:07	67		That didn't work right. It gave an intercept input just after he said beep, and tripped off on angle of attack. Nether one of us is touching it.		
0:27:50			Script Nagoya			
0:33:31			Repeat Script (compass failure)			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:33:55	0:00:00	0				Data Record 11
0:34:10	0:00:15	15	ATC call to Turn			
0:34:51	0:00:56	56	ATC call to Turn			
0:35:08	0:01:13	73	ATC Advisory			
0:35:20	0:01:25	85	ATC Advisory repeat			
0:37:08	0:03:13	193	ATC Switch to Tower			
0:37:42	0:03:47	227	ATC Clearance to Land			
0:38:56	0:05:01	301			Ok. We are starting to pitch up!	
0:38:39	0:04:44	284			Were starting to hard pitch up.	
0:39:00	0:05:05	305			Argh!	
0:39:12	0:05:17	317			And I can't stop the climb.	
0:39:14	0:05:19	319		Ok, and I have control.		
0:39:15	0:05:20	320				VSS Disconnect
0:39:16	0:05:21	321			Ok, you have the controls.	
0:39:23	0:05:28	328			Ok? I thought you said caution wake turbulence on that one. That was a pretty dirty trick.	
0:39:40	0:05:45	345			(Laughs)	
0:39:41	0:05:46	346	I know, let me put my horns on my head.			
0:39:42	0:05:47	347			(Laughs)	
0:40:38			Script Shemya			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:43:39	0:00:00	0				Data Record 13
0:44:28	0:00:49	49			I thought Herman was working pretty good.	
0:44:29	0:00:50	50			I'd better TAKE that GUY off!!	
0:44:30	0:00:51	51				VSS Disconnect
0:44:31	0:00:52	52		I have control.	You have control.	
0:47:14	0:00:00	0	Surprise Birmingham			Data Record 15
0:47:33	0:00:19	19			What the heck are you doing!	
0:47:36	0:00:22	22	(Laughs)	(Laughs) What are you doing? (laughs)	(Laughs) He's playing with me.	
0:47:42	0:00:28	28			(Laughs) Its run away trim, it looks like. (Laughs)	
0:47:47	0:00:33	33		All right, all right, all right, I got it.		
0:47:49	0:00:35	35				VSS Disconnect
0:47:50	0:00:36	36			That was good, Man what a dirty trick he plays on you!	
0:47:51	0:00:37	37	Ok ok ok			
0:47:52	0:00:38	38			You Suck!	
0:47:53	0:00:39	39	(Laughs)			

19.1.6 Subject 6

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(seconds)				
0:00:00			Script Toledo			
0:00:38			Repeat Script			
0:01:17	0:00:00	0				Data Record 9
0:01:27	0:00:10	10	ATC Contact Departure			
0:01:48	0:00:31	31	ATC call to Climb			
0:02:03	0:00:46	46	ATC call to Turn			
0:02:12	0:00:55	55			Ok, over banking.	
0:02:15	0:00:58	58		You have the airplane.		
0:02:25	0:01:08	68			Max power please	
0:02:27	0:01:10	70		Ok.		
0:02:29	0:01:12	72		Ok, very good, let me push this green button.		
0:02:45	0:01:28	88		And I will take the airplane.		
0:02:46	0:01:29	89				VSS Disconnect
0:03:49			Script Birmingham			
0:04:33	0:00:00	0				Data Record 10
0:05:10	0:00:37	37	ATC call to Turn			
0:06:02	0:01:29	89	ATC call to Turn			
0:07:30	0:02:57	177			Approach Flaps	
0:07:31	0:02:58	178		Flaps up		
0:07:32	0:02:59	179			Cancel that!	
0:07:34	0:03:01	181				VSS Disconnect
0:07:36	0:03:03	183		I have the airplane.		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:07:37	0:03:04	184			You have the airplane.	
0:08:43			Script Shemya			
0:09:17	0:00:00	0				Data Record 11
0:09:53	0:00:36	36			Disengage the autopilot please.	
0:10:01	0:00:44	44				VSS Disconnect
0:10:02	0:00:45	45		I have the airplane.		
0:10:03	0:00:46	46			You have the airplane.	
0:12:12			Script Roselawn			
0:12:35			Repeat Script			
0:13:00	0:00:00	0				Data Record 13
0:13:33	0:00:33	33	ATC Speed			
0:14:12	0:01:12	72			I'm going to need the flaps up here.	
0:14:21	0:01:21	81	ATC call to Turn			
0:15:37	0:02:37	157		Ok, I have the airplane		
0:15:40	0:02:40	160				VSS Disconnect
0:17:02			Script Nagoya			
0:17:27			Repeat Script			
0:19:53	0:00:00	0.00				Data Record 16
0:20:09	0:00:16	16.00	ATC call to Turn			
0:21:20	0:01:27	87.00	ATC call to Turn			
0:21:40	0:01:47	107.00	ATC Advisory			
0:23:27	0:03:34	214.00	ATC Switch to Tower			
0:23:42	0:03:49	229.00	ATC Clearance to Land			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:25:38	0:05:45	345.00			Missed approach!	
0:25:40	0:05:47	347.00		Ok.	Positive Rate, Gear up.	
0:25:41	0:05:48	348.00		Gear coming up.		
0:25:42	0:05:49	349.00			Flaps up.	
0:25:43	0:05:50	350.00		Flaps coming up		
0:25:54	0:06:01	361.00			Ok ah…Disengage the trim please.	
0:25:57	0:06:04	364.00		Ok.		
0:25:59	0:06:06	366.00			Emergency Trim please!	
0:26:01	0:06:08	368.00		Alright, I have the airplane		
0:26:02	0:06:09	369.00				VSS Disconnect
0:26:14	0:06:21	381.00		Very good.		
0:27:13			Script Pittsburgh			
0:27:39	0:00:00	0				Data Record 17
0:27:57	0:00:18	18	ATC call to Turn			
0:28:53	0:01:14	74		I have the airplane.		VSS Disconnect
0:37:14			Script Charlotte			
0:37:37	0:00:00	0				Data Record 19
0:37:49	0:00:12	12	ATC call to Turn			
0:38:39	0:01:02	62	ATC call to Turn			
0:41:02	0:03:25	205	ATC Switch to Tower			
0:41:15	0:03:38	218	ATC Clearance to Land			
0:42:27	0:04:50	290			Stick shaker	
0:42:29	0:04:52	292			Max Power	
0:42:31	0:04:54	294		Max power set		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:42:40	0:05:03	303			Gear and flaps up	
0:42:42	0:05:05	305		Gear and flaps up		
0:42:43	0:05:06	306		I have the airplane		
0:42:44	0:05:07	307				VSS Disconnect
0:43:39			Script Detroit			
0:44:04			Repeat Script			
0:44:31	0:00:00	0				Data Record 20
0:45:04	0:00:33	33	ATC call to slow down			
0:45:39	0:01:08	68	ATC call to Turn			
0:45:44	0:01:13	73				VSS Disconnect
0:45:45	0:01:14	74		Ok, I have the airplane.		
0:46:00	0:01:29	89		Ok, now that was fun.		
0:46:02	0:01:31	91			Ya, (laughs)	
0:46:06	0:00:00	0	Surprise Pittsburgh			Data Record 21
0:47:33	0:01:27	87		Ok, I have the airplane.		VSS Disconnect

19.1.7 Subject 7

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(seconds)				
0:00:00			Script Nagoya			
0:00:28	0:00:00	0				Data Record 9
0:00:46	0:00:18	18	ATC call to			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
			Turn			
0:01:31	0:01:03	63	ATC call to Turn			
0:01:52	0:01:24	84	ATC Advisory			
0:03:37	0:03:09	189	ATC Switch to Tower			
0:03:51	0:03:23	203	ATC Clearance to land			
0:05:04	0:04:36	276			What's that?	
0:05:08	0:04:40	280			Hey. Hay, go ahead and help me out with the runaway trim.	
0:05:15	0:04:47	287		Got power set.		
0:05:16	0:04:48	288			OK	
0:05:22	0:04:54	294			Ok, go ahead...Full power	
0:05:25	0:04:57	297		Ok, I have the airplane.		
0:05:26	0:04:58	298				VSS Disconnect
0:05:32	0:05:04	304		And ah the scenario's over.		
0:05:33	0:05:05	305			OK	
0:06:12			Script Toledo			
0:06:47			Repeat Script			
0:07:43	0:00:00	0				Data Record 10
0:07:55	0:00:12	12	ATC Contact Departure			
0:08:13	0:00:30	30	ATC Climb			
0:08:31	0:00:48	48	ATC call to			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
			Turn			
0:08:41	0:00:58	58			Ok I have the aircraft!	
0:08:42	0:00:59	59		You have the aircraft!		
0:08:43	0:01:00	60			I have the aircraft!	
0:09:04	0:01:21	81		Ok very nice.		
0:09:06	0:01:23	83		I have the airplane.		
0:09:07	0:01:24	84			Ok, your aircraft	VSS Disconnect
0:10:27			Script Charlotte			
0:11:05	0:00:00	0				Data Record 11
0:11:16	0:00:11	11	ATC call to Turn			
0:11:56	0:00:51	51	ATC call to Turn			
0:13:42	0:02:37	157	ATC Tower call			
0:13:57	0:02:52	172	ATC Clearance to land			
0:14:25	0:03:20	200		Glide slope's alive.		
0:14:26	0:03:21	201			Ok, glide slope's alive	
0:14:29	0:03:24	204			Ok, I'm thinking ah... Possible windshear out here	
0:14:34	0:03:29	209			Any possible input from the captain on his feelings about it?	
0:14:35	0:03:30	210		I have a hot date tonight down there; I think we should press on.		
0:14:46	0:03:41	221			Give me gear down before landing check	
0:14:48	0:03:43	223		Ok gears coming down		
0:15:10	0:04:05	245			Alright, flaps up, gear up, I feel we have windshear here	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:15:19	0:04:14	254			Notify that we are going around	
0:15:20	0:04:15	255		Ok		
0:15:22	0:04:17	257			Go ahead and start the missed approach procedures	
0:15:25	0:04:20	260	Let's keep it going			
0:15:35	0:04:30	270			Ok I have power	
0:15:45	0:04:40	280		Max power set		
0:15:46	0:04:41	281			Max power set	
0:15:48	0:04:43	283		Ok, I have the airplane		
0:15:49	0:04:44	284			Ok, your aircraft	VSS Disconnect
0:15:50	0:04:45	285		Good		
0:17:36			Script Detroit			
0:18:11	0:00:00	0				Data Record 12
0:18:31	0:00:20	20	ATC call to slow down			
0:19:21	0:01:10	70			Flaps 20	
0:19:23	0:01:12	72		Flaps coming down, ok Flaps set to 20		
0:19:31	0:01:20	80			Ok flaps up!!	
0:19:33	0:01:22	82		Flaps coming up		
0:19:37	0:01:26	86			Ok, give then a radio call and tell them what we got!	
0:19:38	0:01:27	87		What do we got!		
0:19:39	0:01:28	88			Ok we've got Argh...!	
0:19:42	0:01:31	91			We've got Argh. Structural Icing!	
0:19:43	0:01:32	92			VSS Disconnect	
0:19:44	0:01:33	93		I've got the airplane, very good		
0:19:54	0:01:43	103		(Laughs)	(Laughs)...Felt real.	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:20:19	0:02:08	128			That got my heart going a bit.	
0:20:23	0:02:12	132		(Laughs)		
0:21:06			Script Pittsburgh			
0:21:40	0:00:00	0				Data Record 13
0:21:56	0:00:16	16	ATC call to Turn			
0:22:44	0:01:04	64			Owe!!!	
0:22:46	0:01:06	66			Ok, Go ahead and help me with the controls here!!!	
0:22:50	0:01:10	70		Ok I've got my controls	All right! All right!!!!	
0:22:51	0:01:11	71			Pull up!!! Pull up!!!	
0:22:52	0:01:12	72				VSS Disconnect
0:22:53	0:01:13	73		I've got the aircraft		
0:23:05	0:01:25	85			That's the end of that one…I felt like I was on a US Airways 737 on that one.	
0:23:12	0:01:32	92		Well we'll talk about that later.		
0:23:13	0:01:33	93			Wuh Ya!! (Laughs)	
0:24:30			Script Birmingham			
0:25:03	0:00:00	0				Data Record 14
0:25:27	0:00:24	24	ATC call to Turn			
0:26:10	0:01:07	67	ATC call to Turn			
0:27:45	0:02:42	162			Argh!! Ok, Follow me through on this!	
0:27:49	0:02:46	166				VSS Disconnect
0:27:50	0:02:47	167		Ok, I have the airplane		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:28:10	0:03:07	187			Air conditioner on?	
0:28:11	0:03:08	188		Yes it is (laugh)	(Laugh)	
0:28:15	0:03:12	192			I may have to change shirts after all!	
0:28:18	0:03:15	195	That's why we got Two!			
0:29:04			Script Roselawn			
0:29:27			Repeat script			
0:29:55	0:00:00	0				Data Record 15
0:30:19	0:00:24	24	ATC Speed			
0:30:57	0:01:02	62			Lets see if there is a clear area where we can go, because I think we are having a lot of ice build up and we are covered in ice.	
0:31:08	0:01:13	73		Looking outside I don't see anything sir.		
0:31:16	0:01:21	81	ATC call to Turn			
0:31:23	0:01:28	88			Oh.... ok	
0:31:28	0:01:33	93			Flaps up!	
0:31:29	0:01:34	94		Flaps coming up.		
0:31:31	0:01:36	96				VSS Disconnect
0:31:32	0:01:37	97		I have the airplane.		
0:31:59	0:02:04	124			You get to have all the fun over there.	
0:32:02	0:02:07	127		I do.	(Laugh)	
0:32:03	0:02:08	128	(Laugh)	(Laugh)	Ya I figured it out right on the first one of these.	
0:32:54			Script Shemya			
0:33:13	0:00:00	0				Data

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
						Record 16
0:33:57	0:00:44	44				VSS Disconnect
0:33:58	0:00:45	45		Ok, I've got the airplane.		
0:34:50	0:01:37	97		It will be airplane after upset		Data Record 17
0:35:34	0:02:21	141		I have the airplane		VSS Disconnect
0:35:41	0:00:00	0	Nagoya Surprise			Data Record 18
0:38:13	0:02:32	152			Why is it doing that now!	
0:38:15	0:02:34	154			Ok, go ahead and follow me through on this.	
0:38:18	0:02:37	157		Ok		
0:38:19	0:02:38	158			Push!	
0:38:20	0:02:39	159		I'm pushing.		
0:38:30	0:02:49	169			A runaway trim.	
0:38:34	0:02:53	173			Hard to tell from what I have	
0:38:36	0:02:55	175				VSS Disconnect
0:38:37	0:02:56	176		Ok, I have the aircraft		
0:39:03	0:03:22	202			Nasty	
0:39:04	0:03:23	203		Ya we're pretty tricky, but now we won't do anymore.		

19.1.8 Subject 8

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:26				Script Shemya			
0:00:50	0:00:50	0:00:00	0				Data on maintain record 6
0:01:36	0:00:50	0:00:46	46			All right. Ah.	
0:01:40	0:00:50	0:00:50	50			I am going ahead and disconnect.	
0:01:41	0:00:50	0:00:51	51				VSS disconnect
0:01:50	0:00:50	0:01:00	60		Were you pushing when you disconnected?	Yes	
0:03:20				Script for Detroit			
0:03:50	0:03:50	0:00:00	0				Data on maintain record 8
0:04:19	0:03:50	0:00:29	29	ATC call to slow down			
0:05:16	0:03:50	0:01:26	86	ATC call to Turn			
0:05:19	0:03:50	0:01:29	89			Holy smokes.	
0:05:22	0:03:50	0:01:32	92		What's going on there?		
0:05:26	0:03:50	0:01:36	96			You got it.	
0:05:27	0:03:50	0:01:37	97		No, you're flying it.	Okay.	
0:05:32	0:03:50	0:01:42	102			Okay ah…	
0:05:33	0:03:50	0:01:43	103		Okay, I have control.		VSS disconnect
0:05:43	0:03:50	0:01:53	113		Good job. You got it back under control		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:06:51				Script for Nagoya			
0:07:54	0:07:54	0:00:00	0				Maintain record 9
0:08:05	0:07:54	0:00:11	11	ATC turn call			
0:08:35	0:07:54	0:00:41	41	ATC turn call			
0:08:52	0:07:54	0:00:58	58	ATC Advisory			
0:10:13	0:07:54	0:02:19	139	ATC Switch to tower			
0:10:46	0:07:54	0:02:52	172	ATC Clearance to land			
0:12:16	0:07:54	0:04:22	262		.... 500 to minimums.		
0:12:22	0:07:54	0:04:28	268		Okay looking good. Not sinking. We are going above glide slope		
0:12:33	0:07:54	0:04:39	279			Let's go around. Flaps.	
0:12:34	0:07:54	0:04:40	280		Going around. Flaps set		
0:12:36	0:07:54	0:04:42	282			Let's go. Emergency trim.	
0:12:38	0:07:54	0:04:44	284		Emergency trim selected.		
0:12:39	0:07:54	0:04:45	285			Your up.	
0:12:40	0:07:54	0:04:46	286		Selected up.		
0:12:43	0:07:54	0:04:49	289		Watch your speed.		
0:12:44	0:07:54	0:04:50	290			I'm pushing. Ok let's go full power	
0:12:46	0:07:54	0:04:52	292		Full power		
0:12:54	0:07:54	0:05:00	300		Ok I am going to go ahead and take it.		
0:12:58	0:07:54	0:05:04	304				VSS disconnect
0:14:48				Script for Birmingham			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:15:15	0:15:15	0:00:00	0				Data record 0
0:15:40	0:15:15	0:00:25	25	ATC turn call			
0:16:35	0:15:15	0:01:20	80	ATC turn call			
0:18:00	0:15:15	0:02:45	165			Uh! What was that!	
0:18:07	0:15:15	0:02:52	172				VSS disconnect
0:18:08	0:15:15	0:02:53	173		I have control		
0:18:09	0:15:15	0:02:54	174			How come?	
0:18:11	0:15:15	0:02:56	176		You tripped off a little there		
0:19:31				Script for Charlotte			
0:20:15	0:20:15	0:00:00	0				Data record 11
0:20:35	0:20:15	0:00:20	20	ATC turn call			
0:21:12	0:20:15	0:00:57	57	ATC turn call			
0:22:56	0:20:15	0:02:41	161	ATC Tower call			
0:23:11	0:20:15	0:02:56	176	ATC Landing call			
0:24:38	0:20:15	0:04:23	263		You're a little fast there.		
0:24:39	0:20:15	0:04:24	264			Yeah, I'm correcting.	
0:25:38	0:20:15	0:05:23	323			Windshear, windshear!	
0:25:39	0:20:15	0:05:24	324			Ok, max power.	
0:25:40	0:20:15	0:05:25	325		Max power set.		
0:26:05	0:20:15	0:05:50	350		Okay, I will go ahead and take it.		
0:26:07	0:20:15	0:05:52	352				VSS disconnect
0:26:09	0:20:15	0:05:54	354		Nice job.		
0:27:23	0:20:15	0:07:08	428			Windshear is a lot more realistic then in the simulator.	
0:27:24	0:20:15	0:07:09	429		You like that huh?		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:27:56				Script for Roselawn			
0:28:23	0:28:23	0:00:00	0				Data record 12
0:28:58	0:28:23	0:00:35	35	ATC Speed			
0:29:30	0:28:23	0:01:07	67			Something's going on here.	
0:29:31	0:28:23	0:01:08	68		Huh? What do we have?		
0:29:35	0:28:23	0:01:12	72	ATC turn call			
0:31:07	0:28:23	0:02:44	164			All right … uh.	
0:31:13	0:28:23	0:02:50	170				VSS disconnect
0:31:14	0:28:23	0:02:51	171		Okay, I have control.		
0:33:36				Script for Pittsburgh			
0:34:02	0:34:02	0:00:00	0				Data record 13
0:34:18	0:34:02	0:00:16	16	ATC turn call			
0:35:16	0:34:02	0:01:14	74			Uh…Yaw damper off	
0:35:19	0:34:02	0:01:17	77				VSS disconnect
0:35:20	0:34:02	0:01:18	78		I have control.		
0:37:51				Script for Toledo			
0:38:24	0:38:24	0:00:00	0				Data record 14
0:38:43	0:38:24	0:00:19	19	ATC Contact Departure			
0:39:03	0:38:24	0:00:39	39	ATC Climb			
0:39:17	0:38:24	0:00:53	53	ATC turn call			
0:39:27	0:38:24	0:01:03	63			Watch your bank angle there. Bank angle.	
0:39:29	0:38:24	0:01:05	65		I got it?		
0:39:30	0:38:24	0:01:06	66		No, you got it. You got it!		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:39:31	0:38:24	0:01:07	67				VSS disconnect
0:39:32	0:38:24	0:01:08	68		I have control.		
0:39:33	0:38:24	0:01:09	69			Okay.	
0:39:48	0:38:24	0:01:24	84		It tripped off about when took it, it wasn't something did.		
0:00:12	0:00:12	0:00:00	0	Pittsburgh Surprise			Data Record 15
0:02:01	0:00:12	0:01:49	109			You got it.	
0:02:02	0:00:12	0:01:50	110		No. You got it		
0:02:03	0:00:12	0:01:51	111			No!	
0:02:05	0:00:12	0:01:53	113			Are you doing that?	
0:02:06	0:00:12	0:01:54	114		You got it.		
0:02:07	0:00:12	0:01:55	115			No! What do you mean!	
0:02:08	0:00:12	0:01:56	116				VSS disconnect
0:02:09	0:00:12	0:01:57	117		I have control		
0:02:28	0:00:12	0:02:16	136			Huh!	
0:02:30	0:00:12	0:02:18	138			That is awfully scary ah...	
0:02:33	0:00:12	0:02:21	141			They say that those guys could have been able to right that thing huh?	
0:02:50	0:00:12	0:02:38	158			Well that one was the scariest!	

19.2 AERO/NO UPSET GROUP

19.2.1 Subject 1

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Shemya			
0:00:36	0:00:36	0:00:00	0				Data Record 5
0:01:17	0:00:36	0:00:41	41			All right.	
0:01:18	0:00:36	0:00:42	42				VSS Disconnect
0:01:19	0:00:36	0:00:43	43			Disconnecting.	
0:01:20	0:00:36	0:00:44	44		All right, I have control.		
0:03:53				Script Pittsburgh			
0:04:39	0:04:39	0:00:00	0				Data Record 7
0:04:59	0:04:39	0:00:20	20	ATC Call to Turn			
0:05:48	0:04:39	0:01:09	69			All right, What's going on!	
0:05:54	0:04:39	0:01:15	75			All right set max thrust!	
0:05:55	0:04:39	0:01:16	76		Max thrust.		
0:05:56	0:04:39	0:01:17	77			And the rudders, eh feel like their locked up, If you want to take the controls	
0:06:01	0:04:39	0:01:22	82		I can't.		
0:06:02	0:04:39	0:01:23	83			Oh you can't?	
0:06:03	0:04:39	0:01:24	84		I'm helping you but.	Ok.	
0:06:07	0:04:39	0:01:28	88			All right, thrust back.	
0:06:08	0:04:39	0:01:29	89				VSS Disconnect
0:06:09	0:04:39	0:01:30	90		Ok, I have control.		
0:07:30				Script Toledo			

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:08:09	0:08:09	0:00:00	0				Data Record 8
0:08:21	0:08:09	0:00:12	12	ATC Contact Departure			
0:08:41	0:08:09	0:00:32	32	ATC Climb			
0:08:55	0:08:09	0:00:46	46	ATC Call to Turn			
0:09:01	0:08:09	0:00:52	52			All right watch your al...Watch your bank, watch your bank!	
0:09:05	0:08:09	0:00:56	56		You got it?		
0:09:06	0:08:09	0:00:57	57			I got it.	
0:09:13	0:08:09	0:01:04	64			Watch your speed!	
0:09:14	0:08:09	0:01:05	65			Power back a little bit.	
0:09:15	0:08:09	0:01:06	66		You got it?		
0:09:15	0:08:09	0:01:06	66			I got it.	
0:09:21	0:08:09	0:01:12	72			Feels like uh. Did you lose your controls?	
0:09:25	0:08:09	0:01:16	76		No, you got it.		
0:09:28	0:08:09	0:01:19	79			Power back please.	
0:09:33	0:08:09	0:01:24	84			We'll get an airspeed violation here.	
0:09:40	0:08:09	0:01:31	91		Ok, I'll go ahead and take it.		
0:09:41	0:08:09	0:01:32	92				VSS Disconnect
0:09:42	0:08:09	0:01:33	93		I have control.		
0:10:54				Script Roselawn			
0:11:47	0:11:47	0:00:00	0				Data Record 9
0:12:17	0:11:47	0:00:30	30	ATC Speed			
0:12:57	0:11:47	0:01:10	70			It's squirrelly. Watch out. Watch out. Watch out!	

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:13:00	0:11:47	0:01:13	73			Max Thrust!	
0:13:01	0:11:47	0:01:14	74		Ok, max power set.		
0:13:02	0:11:47	0:01:15	75			And let's tell them were aborting.	
0:13:08	0:11:47	0:01:21	81		Ok that's complete, I'll take control.		
0:13:10	0:11:47	0:01:23	83				VSS Disconnect
0:14:23				Script Detroit			
0:15:07	0:15:07	0:00:00	0				Data Record 10
0:15:45	0:15:07	0:00:38	38	ATC Call to Slow Down			
0:16:27	0:15:07	0:01:20	80			Max Thrust!	
0:16:28	0:15:07	0:01:21	81		Max Power.		
0:16:30	0:15:07	0:01:23	83			Easy Baby! Easy, easy, easy!	
0:16:35	0:15:07	0:01:28	88			Easy does it. Bring the power back; I've got the power.	
0:16:37	0:15:07	0:01:30	90		Ok, that's complete. I'll take it.		
0:16:38	0:15:07	0:01:31	91				VSS Disconnect
0:16:39	0:15:07	0:01:32	92		I have control.		
0:17:36				Script Birmingham			
0:18:30	0:18:30	0:00:00	0				Data Record 11
0:18:51	0:18:30	0:00:21	21	ATC Call to Turn			
0:19:47	0:18:30	0:01:17	77	ATC Call to Turn			
0:21:05	0:18:30	0:02:35	155			Argh! Set max thrust sir!	
0:21:06	0:18:30	0:02:36	156		Ok, max thrust set.		

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:21:07	0:18:30	0:02:37	157			All right, we gotta sit right there.	
0:21:08	0:18:30	0:02:38	158		Ok.		
0:21:10	0:18:30	0:02:40	160			Shaker, stick shaker, shaker, shaker!	
0:21:13	0:18:30	0:02:43	163			Max thrust	VSS Disconnect
0:21:14	0:18:30	0:02:44	164		I have control.		
0:23:02				Script Nagoya			
0:23:46	0:23:46	0:00:00	0				Data Record 12
0:23:55	0:23:46	0:00:09	9	ATC Call to Turn			
0:24:43	0:23:46	0:00:57	57	ATC Call to Turn			
0:25:01	0:23:46	0:01:15	75	ATC Advisory			
0:26:29	0:23:46	0:02:43	163	ATC Switch to Tower			
0:27:07	0:23:46	0:03:21	201	ATC Clearance to Land			
0:28:18	0:23:46	0:04:32	272			There was something right there.	
0:28:19	0:23:46	0:04:33	273		Ok, watch you're going high there.		
0:28:20	0:23:46	0:04:34	274			Max thrust!	
0:28:21	0:23:46	0:04:35	275		You're going high	Max thrust!	
0:28:22	0:23:46	0:04:36	276		Max thrust is set.		
0:28:40	0:23:46	0:04:54	294		Watch your airspeed.		
0:28:41	0:23:46	0:04:55	295			Rudder full forward!	
0:28:42	0:23:46	0:04:56	296		Full forward		
0:28:43	0:23:46	0:04:57	297		Watch your airspeed.		
0:28:44	0:23:46	0:04:58	298			Bring the power down.	
0:28:45	0:23:46	0:04:59	299		Ok, I have control.		

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:28:46	0:23:46	0:05:00	300				VSS Disconnect
0:28:47	0:23:46	0:05:01	301			That's all she'll do.	
0:30:02				Script Charlotte			
0:30:50	0:30:50	0:00:00	0				Data Record 13
0:31:08	0:30:50	0:00:18	18	ATC Call to Turn			
0:31:43	0:30:50	0:00:53	53	ATC Call to Turn			
0:33:54	0:30:50	0:03:04	184	ATC Switch to Tower			
0:34:16	0:30:50	0:03:26	206	ATC Clearance to Land			
0:35:57	0:30:50	0:05:07	307			Max Thrust!	
0:35:38	0:30:50	0:04:48	288			Ok, we have a windshear. Yup!	
0:35:39	0:30:50	0:04:49	289		Max thrust set.		
0:36:02	0:30:50	0:05:12	312		No Problem. Max thrust is set.	Sorry about that.	
0:36:05	0:30:50	0:05:15	315			Ok gear up, flaps up.	
0:36:07	0:30:50	0:05:17	317		Ok, gears coming up, flaps coming up. 100 AGL.		
0:36:09	0:30:50	0:05:19	319			All right, here we go.	
0:36:14	0:30:50	0:05:24	324			Lets get positive rate. 160, here we go for the approach.	
0:36:18	0:30:50	0:05:28	328			Still got a shaker over here.	
0:36:20	0:30:50	0:05:30	330			All right.	
0:36:26	0:30:50	0:05:36	336		Ok, I'll take control.		
0:36:27	0:30:50	0:05:37	337				VSS Disconnect
0:36:48	0:36:48	0:00:00	0	Surprise Pittsburgh			Data Record 14

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:37:57	0:36:48	0:01:09	69			Is that us? What happened here?	
0:38:04	0:36:48	0:01:16	76			Alright…	
0:38:12	0:36:48	0:01:24	84		Ok, I'll take control.		
0:38:13	0:36:48	0:01:25	85				VSS Disconnect
0:38:14	0:36:48	0:01:26	86		Ok, I have control.		

19.2.2 Subject 2

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Pittsburgh			
0:00:21	0:00:21	0:00:00	0				Data Record 4
0:00:45	0:00:21	0:00:24	24	ATC Call to Turn			
0:01:40	0:00:21	0:01:19	79		I have the airplane.		VSS Disconnect
0:01:42	0:00:21	0:01:21	81			Whoa!	
0:02:43				Script Detroit			
0:03:12	0:03:12	0:00:00	0				Data Record 5
0:03:45	0:03:12	0:00:33	33	ATC Call to Slow Down			
0:04:52	0:03:12	0:01:40	100				VSS Disconnect
0:04:53	0:03:12	0:01:41	101		Ok, I have the airplane		
0:06:03				Script Charlotte			
0:06:31	0:06:31	0:00:00	0				Data Record 6
0:06:44	0:06:31	0:00:13	13	ATC Call to Turn			
0:07:25	0:06:31	0:00:54	54	ATC Call to Turn			

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:09:33	0:06:31	0:03:02	182	ATC Switch to Tower			
0:09:50	0:06:31	0:03:19	199	ATC Clearance to Land			
0:11:44	0:06:31	0:05:13	313			Gear up! Positive rate, gear up!	
0:11:45	0:06:31	0:05:14	314		Gears up.		
0:11:57	0:06:31	0:05:26	326		Ok		
0:11:58	0:06:31	0:05:27	327		I have the airplane.		VSS Disconnect
0:12:54				Script Toledo			
0:13:36				Script reread			
0:14:20	0:14:20	0:00:00	0				Data Record 7
0:14:32	0:14:20	0:00:12	12	ATC Contact Departure			
0:14:54	0:14:20	0:00:34	34	ATC Climb			
0:15:09	0:14:20	0:00:49	49	ATC Call to Turn			
0:15:18	0:14:20	0:00:58	58			Watch your bank angle!	
0:15:20	0:14:20	0:01:00	60		You have the airplane?!		
0:15:23	0:14:20	0:01:03	63			Oh, I've done that. I'm sorry.	
0:15:27	0:14:20	0:01:07	67			I think I disconnected it.	
0:15:30	0:14:20	0:01:10	70		Ok		
0:15:33	0:14:20	0:01:13	73		Interesting, we are engaged but EP has no control.		
0:15:37	0:14:20	0:01:17	77	Ok, did EP uh, did you hit the green button by any chance.			VSS Disconnect
0:15:39	0:14:20	0:01:19	79	ok		I think I did.	
0:23:42				Script Nagoya 2nd try			
0:24:12	0:24:12	0:00:00	0				Data

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Record 9
0:24:24	0:24:12	0:00:12	12	ATC Call to Turn			
0:25:42	0:24:12	0:01:30	90	ATC Call to Turn			
0:27:28	0:24:12	0:03:16	196	ATC Switch to Tower			
0:27:47	0:24:12	0:03:35	215	ATC Clearance to Land			
0:29:04	0:24:12	0:04:52	292			Wow!	
0:29:30	0:24:12	0:05:18	318			Positive rate, gear up!	
0:29:31	0:24:12	0:05:19	319		Gear coming up.		
0:29:41	0:24:12	0:05:29	329		That's full power.		
0:29:42	0:24:12	0:05:30	330		Ok, I have the airplane.		VSS Disconnect
0:30:33				Script Shemya			
0:31:11	0:31:11	0:00:00	0				Data Record 10
0:31:56	0:31:11	0:00:45	45				VSS Disconnect
0:31:57	0:31:11	0:00:46	46		Ok, I have the airplane.		
0:34:01				Script Roselawn			
0:34:59	0:34:59	0:00:00	0				Data Record 12
0:35:26	0:34:59	0:00:27	27	ATC Speed			
0:36:32	0:34:59	0:01:33	93	ATC Call to Turn			
0:37:03	0:34:59	0:02:04	124		Ok, power set.		
0:37:21	0:34:59	0:02:22	142	ATC Call to Turn			
0:38:57	0:34:59	0:03:58	238		Ok, that's is end of scenario.		
0:38:58	0:34:59	0:03:59	239		I've got it.		VSS Disconnect
0:39:19				Script Birmingham			
0:39:57	0:39:57	0:00:00	0				Data

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Record 13
0:40:26	0:39:57	0:00:29	29	ATC Call to Turn			
0:41:03	0:39:57	0:01:06	66	ATC Call to Turn			
0:42:57	0:39:57	0:03:00	180		Ok, scenario's over.		
0:42:58	0:39:57	0:03:01	181				VSS Disconnect
0:42:59	0:39:57	0:03:02	182		I have the airplane.		
0:43:26	0:43:26	0:00:00	0	Surprise Pittsburgh			Data Record 14
0:45:20	0:43:26	0:01:54	114		I have the airplane.		VSS Disconnect

19.2.3 Subject 3

	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
Time	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Charlotte			
0:00:28	0:00:28	0:00:00	0				Data Record 5
0:01:04	0:00:28	0:00:36	36	ATC Call to Turn			
0:01:47	0:00:28	0:01:19	79	ATC Call to Turn			
0:03:43	0:00:28	0:03:15	195	ATC Switch to Tower			
0:04:05	0:00:28	0:03:37	217	ATC Clearance To Land			
0:06:01	0:00:28	0:05:33	333		Whoa, look at the airspeed we have a windshear!		
0:06:02	0:00:28	0:05:34	334			Max power!	
0:06:03	0:00:28	0:05:35	335	.	Max Power.		
0:06:04	0:00:28	0:05:36	336			Positive rate, gear up!	

0:06:06	0:00:28	0:05:38	338		Ok, gear selected up.		
0:06:09	0:00:28	0:05:41	341			Flaps up!	
0:06:10	0:00:28	0:05:42	342		Flaps selected up.		
0:06:26	0:00:28	0:05:58	358			Stabilize ... speed!	
0:06:30	0:00:28	0:06:02	362			I've got a stick shaker.	
0:06:56	0:00:28	0:06:28	388		Ok, I'll go ahead and take it.		
0:06:57	0:00:28	0:06:29	389		Maneuver complete		VSS Disconnect
0:11:55				Script Shemya			
0:12:23	0:12:23	0:00:00	0				Data Record 7
0:12:52	0:12:23	0:00:29	29			Ok, we have an uncommanded roll; I'm taking off the autopilot.	
0:12:53	0:12:23	0:00:30	30		Ok		
0:12:56	0:12:23	0:00:33	33			I've got a jam.	
0:12:58	0:12:23	0:00:35	35		I've got it now.		
0:12:59	0:12:23	0:00:36	36				VSS Disconnect
0:13:00	0:12:23	0:00:37	37		Ok, I've got control.		
0:18:21				Script Pittsburgh			
0:18:42	0:18:42	0:00:00	0				Data Record 9
0:18:55	0:18:42	0:00:13	13	ATC Call to Turn			
0:19:43	0:18:42	0:01:01	61			I've got a.... rudder control failure.	
0:19:49	0:18:42	0:01:07	67				VSS Disconnect
0:19:50	0:18:42	0:01:08	68		Ok, I've go control.		
0:21:21				Script Toledo			
0:21:59	0:21:59	0:00:00	0				Data Record 10
0:22:14	0:21:59	0:00:15	15	ATC Contact Departure			

0:22:31	0:21:59	0:00:32	32	ATC Climb			
0:22:45	0:21:59	0:00:46	46	ATC Call to Turn			
0:22:55	0:21:59	0:00:56	56			We're rolling. We're rolling!	
0:22:57	0:21:59	0:00:58	58		You got it?		
0:22:59	0:21:59	0:01:00	60			I've got it.	
0:23:01	0:21:59	0:01:02	62		You got it?		
0:23:09	0:21:59	0:01:10	70		Ok, I have control.	Ok	VSS Disconnect
0:25:28				Script Roselawn			
							Data Record 11
0:29:30				Didn't work			VSS Disconnect
0:30:41				Script Detroit			
0:31:07	0:31:07	0:00:00	0				Data Record 12
0:31:35	0:31:07	0:00:28	28	ATC Call to Slow Down			
0:31:51	0:31:07	0:00:44	44			Ok, we're rolling.	
0:31:55	0:31:07	0:00:48	48		Watch you altitude.		
0:32:01	0:31:07	0:00:54	54		Watch you altitude. We're sinking 2000.		
0:32:53	0:31:07	0:01:46	106		Ok I have control.		VSS Disconnect
0:34:05				Script Birmingham			
0:34:37	0:34:37	0:00:00	0				Data Record 13
0:35:00	0:34:37	0:00:23	23	ATC Call to Turn			
0:35:54	0:34:37	0:01:17	77	ATC Call to Turn			

0:37:26	0:34:37	0:02:49	169			Whoa!	
0:37:33	0:34:37	0:02:56	176				VSS Disconnect
0:37:34	0:34:37	0:02:57	177		Ok, I have control.		
0:39:04				Script Nagoya			
0:39:31	0:39:31	0:00:00	0				Data Record 14
0:39:45	0:39:31	0:00:14	14	ATC Call to Turn			
0:40:27	0:39:31	0:00:56	56	ATC Call to Turn			
0:40:57	0:39:31	0:01:26	86	ATC Advisory			
0:42:20	0:39:31	0:02:49	169	ATC Switch to Tower			
0:42:33	0:39:31	0:03:02	182	ATC Clearance to Land			
0:44:12	0:39:31	0:04:41	281			We're slightly high on the glide slope.	
0:44:15	0:39:31	0:04:44	284			Ok.... It's full nose forward I can't do anything.	
0:44:17	0:39:31	0:04:46	286			Going around. Max power!	
0:44:18	0:39:31	0:04:47	287		Ok, I have control.		VSS Disconnect
0:45:38				Script Roselawn 3rd try			
0:46:16	0:46:16	0:00:00	0				Data Record 16
0:46:40	0:46:16	0:00:24	24	ATC Speed			
0:47:12	0:46:16	0:00:56	56			Argh!!	
0:47:14	0:46:16	0:00:58	58				VSS Disconnect
0:47:15	0:46:16	0:00:59	59		Ok, I have control.		
0:47:35	0:47:35	0:00:00	0	Surprise Nagoya			Data Record 17
0:49:37	0:47:35	0:02:02	122			Pitch forward on the runaway trim!	

0:49:41	0:47:35	0:02:06	126			Can I get emergency trim please?	
0:49:42	0:47:35	0:02:07	127		Ok, you have emergency trim.		
0:49:58	0:47:35	0:02:23	143		Ok, I have control.		VSS Disconnect
0:49:59	0:47:35	0:02:24	144		Ok, now it's really over.		
0:50:00	0:47:35	0:02:25	145			Tricky, Tricky.	

19.2.4 Subject 4

Time	Data on Time	Elapsed Time	Elapsed Time	FTE Comments	Safety Pilot Comments	Evaluation Pilot Comments	Computer
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Nagoya			
0:00:26	0:00:26	0:00:00	0				Data Record 5
0:00:47	0:00:26	0:00:21	21	ATC Call to Turn			
0:01:30	0:00:26	0:01:04	64	ATC Call to Turn			
0:01:52	0:00:26	0:01:26	86	ATC Advisory			
0:03:24	0:00:26	0:02:58	178	ATC Switch to Tower			
0:03:37	0:00:26	0:03:11	191	ATC Clearance to Land			
0:05:29	0:00:26	0:05:03	303			I'm getting a nose pitch up.	
0:05:33	0:00:26	0:05:07	307			I've got full forces…nose up, so we're going to have to go ahead and correct.	
0:05:35	0:00:26	0:05:09	309		Ok.	Let's go max power.	
0:05:36	0:00:26	0:05:10	310		Ok, max power.		
0:05:38	0:00:26	0:05:12	312			Positive rate, gear up.	
0:05:39	0:00:26	0:05:13	313		Ok, gears up.		

0:05:41	0:00:26	0:05:15	315		Watch your airspeed; watch your airspeed.		
0:04:43	0:00:26	0:04:17	257			We will go off to the right and try to get out of this guys wake essentially.	
0:04:46	0:00:26	0:04:20	260			Full forward.	
0:04:47	0:00:26	0:04:21	261		Watch your airspeed.		
0:04:48	0:00:26	0:04:22	262		Watch your airspeed.		
0:05:00	0:00:26	0:04:34	274		I've got control	We're going to stall.	VSS Disconnect
0:06:51	0:00:26	0:06:25	385			In debriefing did we say that we have an emergency trim system?	
0:06:54	0:00:26	0:06:28	388		We do, but you have to call for it.	Ok	
0:07:00	0:00:26	0:06:34	394		Were you trying to trim but it didn't work or…	Uh. I started to trim but I didn't think of it until just now. I tried it a little bit.	
0:07:22				Script Charlotte			
0:18:30	0:18:30	0:00:00	0				Data Record 8
0:18:40	0:18:30	0:00:10	10	ATC Call to Turn			
0:19:18	0:18:30	0:00:48	48	ATC Call to Turn			
0:21:21	0:18:30	0:02:51	171	ATC Switch to Tower			
0:21:33	0:18:30	0:03:03	183	ATC Clearance to Land			
0:22:51	0:18:30	0:04:21	261		We're sinking 2500 on the glide scope		
0:22:56	0:18:30	0:04:26	266			That's a little bit abnormal on the sink rate for the glide slope staying on it. We're going to go ahead and go around.	
0:23:00	0:18:30	0:04:30	270			Max power.	

0:23:01	0:18:30	0:04:31	271			Whoa, We've got a Windshear.	
0:23:02	0:18:30	0:04:32	272			Max power.	
0:23:03	0:18:30	0:04:33	273		Max power set.		
0:23:08	0:18:30	0:04:38	278			Firewall power.	
0:23:09	0:18:30	0:04:39	279		Firewall power.		
0:23:10	0:18:30	0:04:40	280		Ok	And pretend a shaker.	
0:23:15	0:18:30	0:04:45	285		Watch your airspeed!		
0:23:16	0:18:30	0:04:46	286			Correcting on the airspeed so we don't stall.	
0:23:26	0:18:30	0:04:56	296			Do you want to keep it level on the climb rate?	
0:23:28	0:18:30	0:04:58	298		Ok		
0:23:36	0:18:30	0:05:06	306			Tell them we will go around.	
0:23:50	0:18:30	0:05:20	320		Ok, let's knock it off.		
0:23:52	0:18:30	0:05:22	322		Ok, I have control.		VSS Disconnect.
0:24:59				Script Shemya			
0:25:17	0:25:17	0:00:00	0				Data Record 9
0:26:11	0:25:17	0:00:54	54			Autopilot off	
0:26:13	0:25:17	0:00:56	56				VSS Disconnect
0:26:15	0:25:17	0:00:58	58		Ok, I have control.		
0:30:50				Script Pittsburgh			
0:31:35	0:31:35	0:00:00	0				Data Record 12
0:31:48	0:31:35	0:00:13	13	ATC Call to Turn			
0:32:34	0:31:35	0:00:59	59			It feels like we have a rudder problem.	
0:32:39	0:31:35	0:01:04	64			Pitching over using the right aileron.	
0:32:47	0:31:35	0:01:12	72			Yep, Yep, I don't have it.	
0:32:49	0:31:35	0:01:14	74			Your aircraft.	VSS

							Disconnect
0:32:50	0:31:35	0:01:15	75		I have control.		
0:33:41				Script Toledo			
0:34:50	0:34:50	0:00:00	0				Data Record 13
0:35:05	0:34:50	0:00:15	15	ATC Contact Departure			
0:35:15	0:34:50	0:00:25	25	ATC Climb			
0:35:37	0:34:50	0:00:47	47	ATC Call to Turn			
0:35:46	0:34:50	0:00:56	56			A little bit excessive on the bank rate.	
0:35:49	0:34:50	0:00:59	59		You got it?		
0:35:50	0:34:50	0:01:00	60			I got it.	VSS Disconnect
0:35:51	0:34:50	0:01:01	61		I got it?		
0:38:45				Script Roselawn			
0:39:32	0:39:32	0:00:00	0				Data Record 14
0:39:57	0:39:32	0:00:25	25	ATC Speed			
0:40:27	0:39:32	0:00:55	55	ATC Call to Turn			
0:40:41	0:39:32	0:01:09	69			Looks like we have a stall!	
0:40:47	0:39:32	0:01:15	75			Max power!	
0:40:48	0:39:32	0:01:16	76		You've got max power.		
0:40:51	0:39:32	0:01:19	79			Resting on the altitude.	
0:40:53	0:39:32	0:01:21	81			What's going on here?	
0:40:55	0:39:32	0:01:23	83			Looks like we keep stalling over on the right side know.	
0:41:00	0:39:32	0:01:28	88			The right wing keeps braking.	

0:41:02	0:39:32	0:01:30	90			Uh. I think maybe we have a lot of ice build up over there, the right wing seems to be uh. Stalling out.	
0:41:09	0:39:32	0:01:37	97		Ok, approach 102; we have some icing problems here, say again the heading.		
0:41:14	0:39:32	0:01:42	102	ATC Call to Turn			
0:41:21	0:39:32	0:01:49	109			And tell them that we would like to keep the airspeed 200 or above if we may.	
0:41:23	0:39:32	0:01:51	111		We would like to keep the airspeed 200 or above Veridian 102.		
0:41:30	0:39:32	0:01:58	118	ATC Approach			
0:41:36	0:39:32	0:02:04	124		Ok, I think we are complete on that one.		
0:41:38	0:39:32	0:02:06	126	Yea good maneuver			
0:41:39	0:39:32	0:02:07	127		Ok I have control		
0:41:40	0:39:32	0:02:08	128				VSS Disconnect
0:43:11				Script Detroit			
0:43:42	0:43:42	0:00:00	0				Data Record 15
0:44:11	0:43:42	0:00:29	29	ATC Call to Slow Down			
0:44:40	0:43:42	0:00:58	58			Max power, looks like the left wing broke. I'm going to go ahead and recover from it.	
0:44:43	0:43:42	0:01:01	61		You've got max power.		
0:44:44	0:43:42	0:01:02	62			Argh!	
0:44:48	0:43:42	0:01:06	66			Let the airspeed built up a little bit now.	
0:44:59	0:43:42	0:01:17	77			It really felt like icing eventually, the controls	

						are really sensitive.	
0:45:03	0:43:42	0:01:21	81		Ok, let me go ahead and take control.		
0:45:04	0:43:42	0:01:22	82		I have control.		VSS Disconnect.
0:46:24				Script Birmingham			
0:50:51	0:50:51	0:00:00	0				Data Record 17
0:51:11	0:50:51	0:00:20	20	ATC Call to Turn			
0:52:07	0:50:51	0:01:16	76	ATC Call to Turn			
0:53:29	0:50:51	0:02:38	158			Whoa, lets go ahead and go around.	
0:53:33	0:50:51	0:02:42	162			We have a little bit of a windshear.	
0:53:34	0:50:51	0:02:43	163		Ok, I have control.		VSS Disconnect
0:56:33				Script Toledo 2nd try			
0:56:50	0:56:50	0:00:00	0				Data Record 18
0:57:28	0:56:50	0:00:38	38	ATC Contact Departure			
0:57:38	0:56:50	0:00:48	48	ATC Climb			
0:57:57	0:56:50	0:01:07	67	ATC Call to Turn			
0:58:05	0:56:50	0:01:15	75			A little excessive on the bank angle there	
0:58:07	0:56:50	0:01:17	77			My aircraft.	
0:58:09	0:56:50	0:01:19	79		What you got it?		
0:58:10	0:56:50	0:01:20	80			Yup, my aircraft.	
0:58:23	0:56:50	0:01:33	93			We've got a lot of roll tendencies to the left.	

						Do you agree?	
0:58:30	0:56:50	0:01:40	100		Could be. Ok, I'll take it.		
0:58:31	0:56:50	0:01:41	101			Your aircraft.	
0:58:32	0:56:50	0:01:42	102		I have control.		VSS Disconnect
0:59:55	0:59:55	0:00:00		Surprise Pittsburgh			Data Record 19
1:01:14	0:59:55	0:01:19	79			Holy Shit what's that!	
1:01:16	0:59:55	0:01:21	81			Ok, autopilot disengaged.	
1:01:19	0:59:55	0:01:24	84		Can you recover?		
1:01:20	0:59:55	0:01:25	85			I believe so.	
1:01:26	0:59:55	0:01:31	91			Your aircraft.	
1:01:27	0:59:55	0:01:32	92		Ok, I'll take it.		VSS Disconnect

19.2.5 Subject 5

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Roselawn			
0:00:57	0:00:57	0:00:00	0				Data Record 4
0:01:30	0:00:57	0:00:33	33	ATC Speed			
0:01:52	0:00:57	0:00:55	55				VSS Disconnect
0:01:53	0:00:57	0:00:56	56		I have control please. I have control.	Ok	
0:03:19				Script Toledo			
0:04:29	0:04:29	0:00:00	0				Data Record 5

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:04:46	0:04:29	0:00:17	17	ATC Contact Departure			
0:05:08	0:04:29	0:00:39	39	ATC Climb			
0:05:23	0:04:29	0:00:54	54	ATC Call to Turn			
0:05:31	0:04:29	0:01:02	62			Easy on the bank! 45, 60 degrees on bank. 60 degrees on bank!	
0:05:33	0:04:29	0:01:04	64		You got it?	Yup!	VSS Disconnect
0:05:34	0:04:29	0:01:05	65		I've got control; ok I've got it back.		
0:09:47				Script Pittsburgh			
0:10:24	0:10:24	0:00:00	0				Data Record 6
0:10:35	0:10:24	0:00:11	11	ATC Call to Turn			
0:11:34	0:10:24	0:01:10	70			Ok, I am lowering the nose, bringing it to the right.	
0:11:36	0:10:24	0:01:12	72			Hard right, right rudder. If you could step on the rudder with me.	
0:11:38	0:10:24	0:01:14	74			Ok, pitching up.	
0:11:39	0:10:24	0:01:15	75		Ok, I have control.	Ok.	VSS Disconnect
0:13:44				Script Shemya			
0:13:58	0:13:58	0:00:00	0				Data Record 7
0:14:45	0:13:58	0:00:47	47			Ok, I'm going to take it off autopilot for a minute here.	
0:14:49	0:13:58	0:00:51	51			Ok, pitch trim runaway, holding the pitch. Would you take the pitch trim runaway off?	
0:14:55	0:13:58	0:00:57	57		Ok.		
0:14:56	0:13:58	0:00:58	58			Disengage the pitch trim.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:14:57	0:13:58	0:00:59	59		Ok, it's disengaged.		
0:15:00	0:13:58	0:01:02	62			It seems like we have something wrong with the elevator there.	
0:15:01	0:13:58	0:01:03	63			Is it disengaged permanently.	
0:15:02	0:13:58	0:01:04	64		Yup.		
0:15:04	0:13:58	0:01:06	66			ok	VSS Disconnect
0:15:05	0:13:58	0:01:07	67		Ok, I have control.	Your airplane.	
0:16:28				Script Charlotte			
0:17:03	0:17:03	0:00:00	0				Data Record 8
0:17:15	0:17:03	0:00:12	12	ATC Call to Turn			
0:17:49	0:17:03	0:00:46	46	ATC Call to Turn			
0:18:05	0:17:03	0:01:02	62			Ok, slightly low, correcting. A little fast.	
0:18:10	0:17:03	0:01:07	67			If I get the positive rate that may help with that.	
0:18:15	0:17:03	0:01:12	72			Sound good.	
0:19:36	0:17:03	0:02:33	153	ATC Switch to Tower			
0:19:49	0:17:03	0:02:46	166	ATC Clearance to Land			
0:21:26	0:17:03	0:04:23	263			Ok, Ref + 25. We're probably going to do a go around here.	
0:21:34	0:17:03	0:04:31	271		Oh, we have a windshear, got a windshear!		
0:21:35	0:17:03	0:04:32	272			Max thrust!	
0:21:37	0:17:03	0:04:34	274		Ok, Max power.	Flaps 9!	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:21:39	0:17:03	0:04:36	276		Flaps 9.		
0:21:40	0:17:03	0:04:37	277			Call the positive rate.	
0:21:42	0:17:03	0:04:39	279			Ok…uh. Don't have it yet.	
0:21:45	0:17:03	0:04:42	282		Positive rate!	Gear up!	
0:21:46	0:17:03	0:04:43	283		Selected up.		
0:21:50	0:17:03	0:04:47	287			How's the speed?	
0:21:53	0:17:03	0:04:50	290		Ok, ah speeds good. Watch your sink rate.		
0:21:55	0:17:03	0:04:52	292			Ok, call the sink rate please.	
0:21:59	0:17:03	0:04:56	296		Right about level… your climbing about 500 now.		
0:22:02	0:17:03	0:04:59	299			All right.	
0:22:05	0:17:03	0:05:02	302			Don't do anything with the radios just yet.	
0:22:08	0:17:03	0:05:05	305			Ok, we got max thrust!	
0:22:09	0:17:03	0:05:06	306		Max thrust.		
0:22:10	0:17:03	0:05:07	307			How's the speed? Is it building?	
0:22:11	0:17:03	0:05:08	308		155		
0:22:12	0:17:03	0:05:09	309			Are we climbing?	
0:22:13	0:17:03	0:05:10	310		Yeah we're climbing now.	Ok, just ride it.	
0:22:16	0:17:03	0:05:13	313		Ok, we're at about 350 AGL.		
0:22:19	0:17:03	0:05:16	316			Small changes.	
0:22:20	0:17:03	0:05:17	317			Small changes.	
0:22:32	0:17:03	0:05:29	329			How's the airspeed?	
0:22:34	0:17:03	0:05:31	331		Airspeed's 160.		
0:22:35	0:17:03	0:05:32	332			Ok that's enough.	VSS Disconnect.

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:22:36	0:17:03	0:05:33	333		I have control.		
0:24:16				Script Nagoya			
0:26:38				Repeat Script			
0:27:04	0:27:04	0:00:00	0				Data Record 9
0:27:19	0:27:04	0:00:15	15	ATC Call to Turn			
0:27:51	0:27:04	0:00:47	47	ATC Call to Turn			
0:28:13	0:27:04	0:01:09	69	ATC Advisory			
0:29:51	0:27:04	0:02:47	167	ATC Switch to Tower			
0:30:13	0:27:04	0:03:09	189	ATC Clearance to Land			
0:31:40	0:27:04	0:04:36	276		Ok you're going high now.	Max thrust.	
0:31:41	0:27:04	0:04:37	277		Ok, max thrust set.		
0:31:42	0:27:04	0:04:38	278			Flaps 9.	
0:31:43	0:27:04	0:04:39	279		Flaps 9		
0:31:45	0:27:04	0:04:41	281			Positive rate.	
0:31:46	0:27:04	0:04:42	282		Positive rate.		
0:31:47	0:27:04	0:04:43	283			Gear down.	
0:31:49	0:27:04	0:04:45	285		Gear coming down.		
0:31:53	0:27:04	0:04:49	289		Watch your speed!		
0:31:55	0:27:04	0:04:51	291			Autotrim, lower the nose, can you trim down please.	
0:31:57	0:27:04	0:04:53	293		Ok, I'm trying.	Ok	
0:31:58	0:27:04	0:04:54	294		Watch your speed!		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:31:59	0:27:04	0:04:55	295			All right.	
0:32:03	0:27:04	0:04:59	299			If you could start descending with the bank here for a minute?	
0:32:07	0:27:04	0:05:03	303			Ok, it's coming down a little bit here.	
0:32:09	0:27:04	0:05:05	305			It's banking a little bit more.	
0:32:13	0:27:04	0:05:09	309			Ok, speed's building	
0:32:14	0:27:04	0:05:10	310		Ok	Hold it in the bank.	
0:32:17	0:27:04	0:05:13	313			Ok, we have a problem here. And uh I am pushing max throat forward, max trim forward, speed's building. Keep from flying away from it.	
0:32:26	0:27:04	0:05:22	322			Ok, I need some full forward pressure here.	
0:32:28	0:27:04	0:05:24	324		Ok	Ok, I need to stay in the bank, declare an emergency; actually don't even worry about that. Just help me out on the process here of what we got to do.	
0:32:36	0:27:04	0:05:32	332		Ok, I'm going to take it.	Ok	
0:32:37	0:27:04	0:05:33	333		Ok, I have control.		VSS Disconnect.
0:32:40	0:27:04	0:05:36	336			Bloody hell. (laughs)	
0:34:15				Script Detroit			
0:34:46	0:34:46	0:00:00	0				Data Record 10
0:35:14	0:34:46	0:00:28	28	ATC Call to Slow Down			
0:36:12	0:34:46	0:01:26	86		Watch you altitude.		
0:36:14	0:34:46	0:01:28	88			Yup. I got it. Thank you.	
0:36:21	0:34:46	0:01:35	95		Ok, I got it.		
0:36:23	0:34:46	0:01:37	97				VSS Disconnect
0:41:20				Script Birmingham			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				2nd attempt			
0:41:53	0:41:53	0:00:00	0				Data Record 12
0:42:00	0:41:53	0:00:07	7	ATC Call to Turn			
0:42:38	0:41:53	0:00:45	45	ATC Call to Turn			
0:43:42	0:41:53	0:01:49	109			I'm Climbing…Deliberately!	
0:43:46	0:41:53	0:01:53	113				VSS Disconnect
0:43:47	0:41:53	0:01:54	114		Ok, I have control.		
0:44:06	0:44:06	0:00:00	0	Surprise Nagoya			Data Record 13
0:45:48	0:44:06	0:01:42	102			Are you doing that? Are you doing that?	
0:46:02	0:44:06	0:01:56	116		Watch your speed here.		
0:46:03	0:44:06	0:01:57	117			Yea you want to disengage it.	
0:46:06	0:44:06	0:02:00	120		Can you recover it?		
0:46:16	0:44:06	0:02:10	130			Pitch trim disengage.	
0:46:25	0:44:06	0:02:19	139			Automatic trim.	
0:46:30	0:44:06	0:02:24	144			Trim runaway.	
0:46:31	0:44:06	0:02:25	145			Probably need a nose trim, see if that works now.	
0:46:35	0:44:06	0:02:29	149			Going around a new bank.	
0:46:36	0:44:06	0:02:30	150			Please control our altitude, although our altitude isn't a problem right now.	
0:46:37	0:44:06	0:02:31	151		Ok.		
0:46:38	0:44:06	0:02:32	152				VSS Disconnect
0:46:40	0:44:06	0:02:34	154		Ok I have control.		

19.2.6 Subject 6

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Detroit			
0:00:43	0:00:43	0:00:00	0				Data Record 5
0:01:04	0:00:43	0:00:21	21	ATC Call to Slow Down			
0:01:55	0:00:43	0:01:12	72				VSS Disconnect
0:01:56	0:00:43	0:01:13	73		Ok, I have the airplane.	You have the airplane.	
0:02:47				Script Charlotte			
0:03:23	0:03:23	0:00:00	0				Data Record 6
0:03:50	0:03:23	0:00:27	27	ATC Call to Turn			
0:04:30	0:03:23	0:01:07	67	ATC Call to Turn			
0:06:19	0:03:23	0:02:56	176	ATC Switch to Tower			
0:06:36	0:03:23	0:03:13	193	ATC Clearance to Land			
0:08:25	0:03:23	0:05:02	302			Ok, turning around. Flaps	
0:08:30	0:03:23	0:05:07	307			Positive rate. Gear up.	
0:08:36	0:03:23	0:05:13	313			Tell tower we're going to miss.	
0:08:42	0:03:23	0:05:19	319		I have the airplane.		VSS Disconnect
0:09:29				Script Toledo			
0:10:26				Repeat Script			
0:11:24	0:11:24	0:00:00	0				Data Record 7
0:11:35	0:11:24	0:00:11	11	ATC Contact Departure			
0:11:47	0:11:24	0:00:23	23	ATC Climb			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:12:12	0:11:24	0:00:48	48	ATC Call to Turn			
0:12:19	0:11:24	0:00:55	55			Bank angle? Bank angle?	
0:12:23	0:11:24	0:00:59	59			I have the controls!	
0:12:24	0:11:24	0:01:00	60		You have it?	I have it!	
0:12:43	0:11:24	0:01:19	79		Ok, I have the airplane.	You have the airplane.	VSS Disconnect
0:13:54				Script Nagoya			
0:14:16	0:14:16	0:00:00	0				Data Record 8
0:14:26	0:14:16	0:00:10	10	ATC Call to Turn			
0:15:35	0:14:16	0:01:19	79	ATC Call to Turn			
0:16:03	0:14:16	0:01:47	107	ATC Advisory			
0:17:41	0:14:16	0:03:25	205	ATC Switch to Tower			
0:18:00	0:14:16	0:03:44	224	ATC Clearance to Land			
0:19:33	0:14:16	0:05:17	317			All right, going around.	
0:19:36	0:14:16	0:05:20	320			Go around power.	
0:19:37	0:14:16	0:05:21	321		Ok, you have go around power.		
0:19:38	0:14:16	0:05:22	322			Positive rate, gear up.	
0:19:39	0:14:16	0:05:23	323			Gear coming up.	
0:19:41	0:14:16	0:05:25	325			And emergency trim.	VSS Disconnect
0:19:42	0:14:16	0:05:26	326		I have the airplane.		
0:20:36				Script Shemya			
0:21:04	0:21:04	0:00:00	0				Data Record 9
0:21:48	0:21:04	0:00:44	44				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:23:24				Script Roselawn			
0:23:57	0:23:57	0:00:00	0				Data Record 11
0:24:32	0:23:57	0:00:35	35	ATC Speed			
0:24:50	0:23:57	0:00:53	53			Oh...That sucks!	
0:25:00	0:23:57	0:01:03	63			You may want to tell them that.........Argh a little trouble.	
0:25:04	0:23:57	0:01:07	67			Uh...We have a little trouble.	
0:25:06	0:23:57	0:01:09	69			(Laughs) Good request. 4000 Feet.	
0:25:17	0:23:57	0:01:20	80	ATC Call to Turn			
0:25:31	0:23:57	0:01:34	94		Ok I'll take the airplane.		
0:25:32	0:23:57	0:01:35	95				VSS Disconnect.
0:26:47				Script Birmingham			
0:27:12	0:27:12	0:00:00	0				Data Record 12
0:27:25	0:27:12	0:00:13	13	ATC Call to Turn			
0:28:05	0:27:12	0:00:53	53	ATC Call to Turn			
0:29:23	0:27:12	0:02:11	131			Yes!	
0:29:31	0:27:12	0:02:19	139			Argh, ah. Emergency trim!	
0:29:32	0:27:12	0:02:20	140		You've got emergency trim.		
0:29:36	0:27:12	0:02:24	144			Ok, give me max power.	
0:29:37	0:27:12	0:02:25	145		Ok I have the airplane.		VSS Disconnect
0:29:38	0:27:12	0:02:26	146			You have the airplane.	
0:30:45				Script Pittsburgh			
0:31:21	0:31:21	0:00:00	0				Data Record 13

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:31:37	0:31:21	0:00:16	16	ATC Call to Turn			
0:32:38	0:31:21	0:01:17	77		All right.		VSS Disconnect
0:32:39	0:31:21	0:01:18	78		I have the airplane		
0:32:41	0:31:21	0:01:20	80			You have the airplane.	
0:33:06	0:33:06	0:00:00	0	Surprise Nagoya			Data Record 14
0:34:31	0:33:06	0:01:25	85			That's strange.	
0:34:34	0:33:06	0:01:28	88			I keep waiting for the next event.	
0:34:40	0:33:06	0:01:34	94			Which is uh … emergency trim.	
0:34:43	0:33:06	0:01:37	97		Ok, you have emergency trim.		
0:34:50	0:33:06	0:01:44	104				VSS Disconnect
0:34:51	0:33:06	0:01:45	105		Ok, I have the airplane.		
0:34:52	0:33:06	0:01:46	106			Haaaaa…. Clever!	

19.2.7 Subject 7

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Birmingham			
0:00:42	0:00:42	0:00:00	0				Data Record 5
0:00:58	0:00:42	0:00:16	16	ATC Call to Turn			
0:01:43	0:00:42	0:01:01	61	ATC Call to Turn			
0:03:10	0:00:42	0:02:28	148		Ok, I have control.		VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:05:24				Script Shemya			
0:05:46	0:05:46	0:00:00	0				Data Record 6
0:06:20	0:05:46	0:00:34	34			We're getting a little play in the left aileron.	
0:06:24	0:05:46	0:00:38	38			Whoa!	VSS Disconnect
0:06:25	0:05:46	0:00:39	39		Ok, I have control.		
0:10:46				Script Roselawn			
0:11:12	0:11:12	0:00:00	0				Data Record 8
0:11:46	0:11:12	0:00:34	34	ATC Speed			
0:12:12	0:11:12	0:01:00	60			Ok, flaps twenty!	
0:12:14	0:11:12	0:01:02	62		Flaps coming back down.		
0:12:18	0:11:12	0:01:06	66		Ok, flaps are 20.		
0:12:21	0:11:12	0:01:09	69			AARRGGHH MAN!!!!!	
0:12:28	0:11:12	0:01:16	76		Correct.	We 're still flying south bound correct?	
0:12:33	0:11:12	0:01:21	81		Ok, I have control.		
0:13:34	0:11:12	0:02:22	142				VSS Disconnect
0:13:24				Script Nagoya			
0:14:06	0:14:06	0:00:00	0				Data Record 9
0:14:19	0:14:06	0:00:13	13	ATC Call to Turn			
0:15:00	0:14:06	0:00:54	54	ATC Call to Turn			
0:15:14	0:14:06	0:01:08	68	ATC Advisory			
0:16:44	0:14:06	0:02:38	158	ATC Switch to Tower			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:16:56	0:14:06	0:02:50	170	ATC Clearance to Land			
0:18:53	0:14:06	0:04:47	287		Ok, we're going high. We're going high.	Ok.	
0:18:56	0:14:06	0:04:50	290			All right, I have stick pressure here.	
0:19:05	0:14:06	0:04:59	299			There's the stick shaker.	
0:19:10	0:14:06	0:05:04	304				VSS Disconnect
0:19:11	0:14:06	0:05:05	305		Ok I have control.	Huh, your airplane.	
0:20:21				Script Pittsburgh			
0:21:02	0:21:02	0:00:00	0				Data Record 10
0:21:12	0:21:02	0:00:10	10	ATC Call to Turn			
0:22:04	0:21:02	0:01:02	62			AARRGGHH MAN!!!!!	
0:22:11	0:21:02	0:01:09	69		I have Control.		VSS Disconnect
0:22:16	0:21:02	0:01:14	74			All right, Whoa!	
0:23:28				Script Charlotte			
0:24:06	0:24:06	0:00:00	0				Data Record 11
0:24:15	0:24:06	0:00:09	9	ATC Call to Turn			
0:24:46	0:24:06	0:00:40	40	ATC Call to Turn			
0:26:23	0:24:06	0:02:17	137	ATC Switch to Tower			
0:26:36	0:24:06	0:02:30	150	ATC Clearance to Land			
0:28:47	0:24:06	0:04:41	281		Oh, we've got a		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
					windshear, a windshear!		
0:28:53	0:24:06	0:04:47	287		Maxpower		
0:29:00	0:24:06	0:04:54	294		ok	Tell Denver tower that we are going around.	
0:29:01	0:24:06	0:04:55	295		Ok, I have control.	Huh.	VSS Disconnect
0:30:36				Script Detroit			
0:31:12	0:31:12	0:00:00	0				Data Record 12
0:31:43	0:31:12	0:00:31	31	ATC Call to Slow Down			
0:32:26	0:31:12	0:01:14	74			(Laughs) Geese!	
0:32:29	0:31:12	0:01:17	77				VSS Disconnect
0:32:30	0:31:12	0:01:18	78		Ok, I have control.	Your. (Laughs)	
0:33:55				Script Toledo			
0:34:31	0:34:31	0:00:00	0				Data Record 13
0:34:47	0:34:31	0:00:16	16	ATC Contact Departure			
0:35:02	0:34:31	0:00:31	31	ATC Climb			
0:35:23	0:34:31	0:00:52	52	ATC Call to Turn			
0:35:32	0:34:31	0:01:01	61			Ok, sir, you're over set on the bank. Sir?	
0:35:34	0:34:31	0:01:03	63		You got it?	What's your bank?	
0:35:42	0:34:31	0:01:11	71		You got it?		
0:35:43	0:34:31	0:01:12	72			Ok, we're coming in. Max power and we're climbing again.	
0:35:48	0:34:31	0:01:17	77		Ok, I'll take it.		
0:35:49	0:34:31	0:01:18	78				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:36:02	0:36:02	0:00:00	0	Surprise Nagoya			Data Record 14
0:37:45	0:36:02	0:01:43	103			Is that you? Are you still doing something to me?	
0:37:50	0:36:02	0:01:48	108			Help we've got a problem, were going up! (laughs)	
0:37:56	0:36:02	0:01:54	114			I've got full elevator pressure. Do you want to help me on the elevator pressure?	
0:38:00	0:36:02	0:01:58	118				VSS Disconnect
0:38:01	0:36:02	0:01:59	119		Ok, I have control.	(Laughs)	

19.2.8 Subject 8

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Birmingham			
0:00:30	0:00:30	0:00:00	0				Data Record 5
0:00:47	0:00:30	0:00:17	17	ATC Call to Turn			
0:01:25	0:00:30	0:00:55	55	ATC Call to Turn			
0:02:59	0:00:30	0:02:29	149		I have the airplane.	Ahh.	VSS Disconnect
0:03:57				Script Detroit			
0:04:52	0:04:52	0:00:00	0				Data Record 6
0:05:27	0:04:52	0:00:35	35	ATC Call to Slow Down			
0:06:07	0:04:52	0:01:15	75			We're getting the warning, Max power!	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:06:10	0:04:52	0:01:18	78		Power set.		
0:06:14	0:04:52	0:01:22	82			Ok, that was a tailplane stall or something.	
0:06:16	0:04:52	0:01:24	84			Argh there it goes again! Come on!	
0:06:18	0:04:52	0:01:26	86			Let's roll with the rudders. There it is. Ok.	
0:06:23	0:04:52	0:01:31	91			Ok, I've regained control.	
0:06:26	0:04:52	0:01:34	94	ATC Call To Turn			
0:06:28	0:04:52	0:01:36	96		Ok, I'll take the airplane.		
0:06:29	0:04:52	0:01:37	97				VSS Disconnect
0:08:00				Script Roselawn			
0:08:28	0:08:28	0:00:00	0				Data Record 7
0:08:56	0:08:28	0:00:28	28	ATC Speed			
0:09:15	0:08:28	0:00:47	47			Argh. Where's it going! Come on Baby!	
0:09:19	0:08:28	0:00:51	51			There it is! ...... Bear with me.	
0:09:23	0:08:28	0:00:55	55			Argh...Trim runaway, emergency trim PLEASE!	
0:09:33	0:08:28	0:01:05	65		All right, I have the airplane.		VSS Disconnect
0:10:29				Script Toledo			
0:11:08	0:11:08	0:00:00	0				Data Record 8
0:11:18	0:11:08	0:00:10	10	ATC Contact Departure			
0:11:35	0:11:08	0:00:27	27	ATC Climb			
0:11:55	0:11:08	0:00:47	47	ATC Call to Turn			
0:12:04	0:11:08	0:00:56	56			What are you doing here captain?	
0:12:06	0:11:08	0:00:58	58			Watch your pitch!	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:12:07	0:11:08	0:00:59	59		You have the airplane!	I have the airplane.	
0:12:12	0:11:08	0:01:04	64			You've got to be recoverable. There it is...ok.	
0:12:14	0:11:08	0:01:06	66		Max power.	Get up. Get up. Get up.	
0:12:22	0:11:08	0:01:14	74			There we go.	
0:12:28	0:11:08	0:01:20	80		Press the green button.	All right we got a.........green buttons pressed.	
0:12:31	0:11:08	0:01:23	83		Thank you...I'll take the airplane.		
0:31:33	0:11:08	0:20:25	1225			You've got the airplane.	VSS Disconnect
0:13:25				Script Pittsburgh			
0:14:14	0:14:14	0:00:00	0				Data Record 9
0:14:30	0:14:14	0:00:16	16	ATC Call to Turn			
0:15:17	0:14:14	0:01:03	63			Ok, I've got a rudder jam. I need emergency rudder trim.... Ah is a hard over! Max power!	
0:15:25	0:14:14	0:01:11	71		Ok, I have the airplane.	Damn!	VSS Disconnect
0:15:35	0:14:14	0:01:21	81		Good Call.		
0:15:38	0:14:14	0:01:24	84			I didn't have enough speed.	
0:15:42	0:14:14	0:01:28	88		Ok, we can talk about that later, good one.		
0:16:30				Script Shemya			
0:17:19	0:17:19	0:00:00	0				Data Record 10
0:17:59	0:17:19	0:00:40	40			What's going on? Is that a surface jam?	
0:18:00	0:17:19	0:00:41	41			No, the autopilot it dying on me.	
0:18:05	0:17:19	0:00:46	46			Whoa!	VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:18:06	0:17:19	0:00:47	47		I have the airplane.		
0:20:50				Script Charlotte			
0:21:19	0:21:19	0:00:00	0				Data Record 12
0:21:33	0:21:19	0:00:14	14	ATC Call to Turn			
0:22:22	0:21:19	0:01:03	63	ATC Call to Turn			
0:24:39	0:21:19	0:03:20	200	ATC Switch to Tower			
0:24:53	0:21:19	0:03:34	214	ATC Clearance to Land			
0:25:00	0:21:19	0:03:41	221		Glide slope's alive.		
0:25:03	0:21:19	0:03:44	224		That's one dot above.	Go ahead and throw out the wheels.	
0:25:09	0:21:19	0:03:50	230			Come on baby where are you going?	
0:25:34	0:21:19	0:04:15	255			Ah, come back.	
0:26:36	0:21:19	0:05:17	317			Max power.	
0:26:37	0:21:19	0:05:18	318		Max power.		
0:26:40	0:21:19	0:05:21	321			Come on ...Get up. Get up.	
0:26:43	0:21:19	0:05:24	324			Positive rate. Gear up.	
0:26:51	0:21:19	0:05:32	332			Windshear here.	
0:26:59	0:21:19	0:05:40	340		Ok, that's good. I have the airplane	You have the airplane.	VSS Disconnect
0:27:38				Script Nagoya			
0:28:52	0:28:52	0:00:00	0				Data Record 13
0:29:12	0:28:52	0:00:20	20	ATC Call to Turn			
0:29:59	0:28:52	0:01:07	67	ATC Call to			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Turn			
0:30:17	0:28:52	0:01:25	85	ATC Advisory			
0:31:53	0:28:52	0:03:01	181	ATC Switch to Tower			
0:32:08	0:28:52	0:03:16	196	ATC Clearance to Land			
0:33:53	0:28:52	0:05:01	301			What do we have a runaway pitch or something?	
0:33:57	0:28:52	0:05:05	305			What's this all about? Max Power.	
0:33:58	0:28:52	0:05:06	306		Max Power	That was down trim if you could on the orders.	
0:34:00	0:28:52	0:05:08	308		Ok, Emergency Trim. You've got it.		
0:34:04	0:28:52	0:05:12	312			Ok, come on baby it's coming down, there it comes, come on get down get down!	
0:34:11	0:28:52	0:05:19	319		All right I'll take it.		
0:34:12	0:28:52	0:05:20	320				VSS Disconnect
0:34:13	0:28:52	0:05:21	321			You have the controls.	
0:34:56				Surprise Birmingham			Data Record 14
0:35:47	0:35:47	0:00:00	0			What's going on!	
0:35:48	0:35:47	0:00:01	1				VSS Disconnect
0:35:49	0:35:47	0:00:02	2		Ok, I have the airplane.		

19.3 NO AERO/ UPSET GROUP

19.3.1 Subject 1

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(Seconds)				
0:00:00			Script Toledo			
0:00:41	0:00:00	0				Data Record 5
0:00:48	0:00:07	7	ATC Contact Departure			
0:01:04	0:00:23	23	ATC Climb			
0:01:26	0:00:45	45	ATC call to Turn			
0:01:32	0:00:51	51			We've got a high sink rate going.	
0:01:36	0:00:55	55			My airplane.	
0:01:37	0:00:56	56		You got it.	Yup.	
0:01:50	0:01:09	69		Ok, I'll take it back here …		
0:01:53	0:01:12	72				VSS Disconnect
0:01:54	0:01:13	73		I have Control.		
0:02:32			Script Nagoya			
0:03:12	0:00:00	0				Data Record 6
0:03:26	0:00:14	14	ATC call to Turn			
0:04:03	0:00:51	51	ATC call to Turn			
0:04:18	0:01:06	66	ATC Advisory			
0:05:36	0:02:24	144	ATC Switch to Tower			
0:05:48	0:02:36	156	ATC Clearance to Land			
0:08:13	0:05:01	301				VSS Disconnect
0:08:14	0:05:02	302		Ok, I have the airplane.		
0:09:35			Script Shemya			
0:10:11	0:00:00	0				Data Record 7
0:10:56	0:00:45	45			Max Power	VSS Disconnect
0:10:57	0:00:46	46		Ok, I have control.		
0:13:45			Script Roselawn			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:14:32	0:00:00	0				Data Record 9
0:15:03	0:00:31	31	ATC speed			
0:15:40	0:01:08	68	ATC call to Turn			
0:16:09	0:01:37	97				VSS Disconnect
0:16:10	0:01:38	98		Ok, I have control of the airplane.		
0:17:12			Script Birmingham			
0:17:45	0:00:00	0				Data Record 10
0:17:57	0:00:12	12	ATC call to Turn			
0:18:32	0:00:47	47	ATC call to Turn			
0:19:44	0:01:59	119				VSS Disconnect
0:19:45	0:02:00	120		Ok, I have control.		
0:20:56			Script Pittsburgh			
0:21:23	0:00:00	0				Data Record 11
0:21:33	0:00:10	10	ATC call to Turn			
0:22:20	0:00:57	57				VSS Disconnect
0:22:21	0:00:58	58		Ok, I have Control.		
0:23:30			Script Detroit			
0:23:59	0:00:00	0				Data Record 12
0:24:21	0:00:22	22	ATC call to Slow down			
0:24:55	0:00:56	56			(Says "Jesus" under breath)	
0:24:58	0:00:59	59			(Laughs Nervously)	
0:25:12	0:01:13	73				VSS Disconnect
0:25:13	0:01:14	74		Ok, I have Control.		
0:25:17	0:01:18	78		That was a fun one huh,	(laughs)	
0:26:14			Script Charlotte			
0:26:46	0:00:00	0				Data Record 13
0:27:00	0:00:14	14	ATC call to Turn			
0:27:33	0:00:47	47	ATC call to Turn			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:28:53	0:02:07	127	ATC Switch to Tower			
0:29:05	0:02:19	139	ATC Clearance to Land			
0:31:09	0:04:23	263		uh...Windshear, Windshear		
0:31:10	0:04:24	264			Escape!	
0:31:11	0:04:25	265		ok.		
0:31:20	0:04:34	274		Max power set.		
0:31:31	0:04:45	285		ok, I'll take it.		
0:31:32	0:04:46	286				VSS Disconnect
0:31:50	0:00:00	0	Surprise Pittsburgh			Data Record 14
0:33:00	0:01:10	70			Oh!	
0:33:12	0:01:22	82		Ok, I have Control		VSS Disconnect

19.3.2 Subject 2

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(Seconds)				
0:00:00			Script Pittsburgh			
0:00:39	0:00:00	0				Data Record 5
0:00:49	0:00:10	10	ATC call to Turn			
0:01:32	0:00:53	53			Ok, we seem to have a roll upset here.	
0:01:35	0:00:56	56				VSS Disconnect
0:01:36	0:00:57	57		I have control.		
0:03:08			Script Shemya			
0:03:27	0:00:00	0				Data Record 6

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:04:05	0:00:38	38			The airplane seems to be putting in a bank and off pitch. Disengage autopilot!	
0:04:08	0:00:41	41				VSS Disconnect
0:04:09	0:00:42	42		Ok, I have Control.		
0:06:47			Script Charlotte			
0:07:40	0:00:00	0				Data Record 8
0:07:57	0:00:17	17	ATC call to Turn			
0:08:42	0:01:02	62	ATC call to Turn			
0:10:24	0:02:44	164	ATC Switch to Tower			
0:10:36	0:02:56	176	ATC Clearance to Land			
0:12:32	0:04:52	292			We are a little low. We've got 200 minimums. We have a Windshear, a Windshear!	
0:12:37	0:04:57	297			Max thrust.	
0:12:38	0:04:58	298		Max thrust set.		
0:12:39	0:04:59	299			Go around.	
0:12:41	0:05:01	301		Max thrust set.		
0:12:42	0:05:02	302			Good to go around, bars, see if I can get my windshear guidance.	
0:12:46	0:05:06	306		Yea, you don't have it.	Ok.	
0:12:48	0:05:08	308			Maintain Configuration.	
0:12:50	0:05:10	310		Airspeed?		
0:12:51	0:05:11	311			Give me trends please on my radar altimeter.	
0:12:54	0:05:14	314		Ok, your 800, 800 AGL and		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				climbing. Ok watch your speed.		
0:12:57	0:05:17	317		Ok, that's good. I have control.		
0:12:59	0:05:19	319		Good Job		VSS Disconnect
0:13:16	0:05:36	336			That was simulated that we were going that slow right, we weren't really doing 110 KIAS.	
0:13:17	0:05:37	337		No, we were not.		
0:13:19	0:05:39	339			Huh,..................I did not like that.	
0:14:19			Script Nagoya			
0:15:00	0:00:00	0				Data Record 9
0:15:13	0:00:13	13	ATC call to Turn			
0:16:00	0:01:00	60	ATC call to Turn			
0:16:22	0:01:22	82	ATC Advisory			
0:17:44	0:02:44	164	ATC Switch to Tower			
0:18:00	0:03:00	180	ATC Clearance to Land			
0:19:54	0:04:54	294			ARGH.... We're getting a little bit of a trim runaway here.	
0:19:57	0:04:57	297			Looks like ... I can't seem to get the nose down ... I thinks it a runaway trim.	
0:20:02	0:05:02	302			I'm disconnecting.	
0:20:03	0:05:03	303			Emergency trim!	
0:20:04	0:05:04	304		Ok, emergency trim selected.		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:20:15	0:05:15	315			It's…starting to come around a little bit now.	
0:20:18	0:05:18	318			Starting to get a little buffet.	
0:20:21	0:05:21	321			Nose is coming down.	
0:20:24	0:05:24	324		Airspeed is real low here.	Buffet…. Airspeed is decreasing	
0:20:29	0:05:29	329			Ok, buffet is going away. Airspeed is increasing.	
0:20:37	0:05:37	337			Ok……it looks like we have it under control here.	
0:20:41	0:05:41	341		Ok, I have control.	Tell ATC we had a flight control malfunction and we were flying an emergency.	VSS Disconnect
0:21:27			Script Detroit			
0:21:57	0:00:00	0				Data Record 10
0:22:24	0:00:27	27	ATC call to Slow Down			
0:22:30	0:00:33	33			Ok. We 're getting a roll over here.	
0:22:33	0:00:36	36			O O O…! Out of control!	
0:22:38	0:00:41	41			All right. It's starting to come back around.	
0:22:41	0:00:44	44				VSS Disconnect
0:22:42	0:00:45	45		All right, I have control.		
0:22:43	0:00:46	46			Ok.. Your control!	
0:22:50	0:00:53	53			What the……Hell was that!	
0:22:53	0:00:56	56		That was a good one huh.		
0:22:54	0:00:57	57	Yea that was very nice.			
0:23:49			Script Birmingham			
0:24:34	0:00:00	0				Data Record 11

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:24:42	0:00:08	8	ATC call to Turn			
0:25:19	0:00:45	45	ATC call to Turn			
0:26:28	0:01:54	114			Ohh, Roll!	
0:26:34	0:02:00	120			Alright…	
0:26:37	0:02:03	123			Loosen some airspeed here.	
0:26:39	0:02:05	125			Emergency Trim!	
0:26:40	0:02:06	126		I have Control.		VSS Disconnect
0:26:44	0:02:10	130			What the hell was that?	
0:26:46	0:02:12	132		I took it; we were going a little to fast nose up.		
0:27:30			Script Roselawn			
0:28:12	0:00:00	0				Data Record 12
0:28:39	0:00:27	27	ATC Speed			
0:28:59	0:00:47	47			Ok we got a. … asymmetry, asymmetry!	
0:29:02	0:00:50	50				VSS Disconnect
0:29:03	0:00:51	51		I have control.		
0:30:31			Script Toledo			
0:31:13	0:00:00	0				Data Record 13
0:31:27	0:00:14	14	ATC Contact Departure			
0:31:40	0:00:27	27	ATC climb			
0:31:58	0:00:45	45	ATC call to			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
			Turn			
0:32:06	0:00:53	53			Ok, We're in a pretty steep roll, Cap. Are you going to take it over, I've got it.	
0:32:10	0:00:57	57		You got it?	I've got it?	
0:32:14	0:01:01	61			Max power!	
0:32:15	0:01:02	62		Max Power set.		
0:32:26	0:01:13	73		Ok, I'll go ahead and take it.		
0:32:27	0:01:14	74				VSS Disconnect
0:32:28	0:01:15	75		I have control.		
0:33:40	0:00:00	0	Surprise Pittsburgh			Data Record 14
0:34:51	0:01:11	71			Ok, We have an asymmetry here.	
0:34:54	0:01:14	74			The rudder just snatched on me.	
0:35:00	0:01:20	80			I've Got…Full Right…Rudder here, and a whole lotta pedal.	
0:35:12	0:01:32	92			Ok, do we have a full reverse rudder problem?	
0:35:20	0:01:40	100		Ok, I'll Take it.		
0:35:21	0:01:41	101				VSS Disconnect

19.3.3 Subject 3

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(Seconds)				
0:00:00			Script Roselawn			
0:00:49	0:00:00	0				Data Record 5
0:01:13	0:00:24	24	ATC Speed			
0:01:42	0:00:53	53			Ok, we've got a stall.	
0:01:50	0:01:01	61			Go ahead and push the nose down, recover.	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:01:52	0:01:03	63		Ok, I have the airplane.		VSS Disconnect
0:06:23			Script Shemya			
0:09:45	0:00:00	0				Data Record 9
0:09:56	0:00:11	11	Problem 3rd try			VSS Disconnect
0:15:05			Script Birmingham			
0:15:29	0:00:00	0				Data Record 11
0:15:47	0:00:18	18	ATC call to Turn			
0:16:15	0:00:46	46	ATC call to Turn			
0:17:08	0:01:39	99				VSS Disconnect
0:17:09	0:01:40	100		I have the airplane.	I'm sorry.	
0:17:10	0:01:41	101		That's good, my airplane.		
0:27:47			Script Toledo			
0:28:22	0:00:00	0				Data Record 13
0:28:40	0:00:18	18	2x	Rudder Problem		VSS Disconnect
0:29:44			Script Detroit			
0:30:22	0:00:00	0				Data Record 14
0:30:26	0:00:04	4				VSS Disconnect
0:31:18			Tape Ends			

19.3.4 Subject 4

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Pittsburgh			
0:00:35	0:00:35	0:00:00	0				Data Record 5
0:00:46	0:00:35	0:00:11	11	ATC Call to Turn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:01:40	0:00:35	0:01:05	65			Wuh!!	
0:02:04	0:00:35	0:01:29	89			I need trim.	
0:02:05	0:00:35	0:01:30	90		Ok, I'll take it now.		
0:02:08	0:00:35	0:01:33	93				VSS Disconnect
0:02:09	0:00:35	0:01:34	94		I have control.		
0:02:41				Script Toledo			
0:04:23	0:04:23	0:00:00	0				Data Record 6
0:04:31	0:04:23	0:00:08	8	ATC Contact Departure			
0:04:44	0:04:23	0:00:21	21	ATC Climb			
0:05:08	0:04:23	0:00:45	45	ATC Call to Turn			
0:05:17	0:04:23	0:00:54	54			Whoa, Watch you bank. Watch your bank!!	
0:05:21	0:04:23	0:00:58	58		You got it?		
0:05:25	0:04:23	0:01:02	62				VSS Disconnect
0:05:26	0:04:23	0:01:03	63		Ok, I have control.		
0:06:54				Script Roselawn			
0:07:56	0:07:56	0:00:00	0				Data Record 7
0:08:22	0:07:56	0:00:26	26	ATC Speed			
0:08:51	0:07:56	0:00:55	55			Whoa, argh!!!	
0:09:04	0:07:56	0:01:08	68			And it does it again!	
0:09:12	0:07:56	0:01:16	76		Ok, watch your altitude!		
0:09:24	0:07:56	0:01:28	88		Ok		
0:09:26	0:07:56	0:01:30	90				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:09:27	0:07:56	0:01:31	91		Ok, I have control.		
0:12:21				Script Detroit			
0:12:47	0:12:47	0:00:00	0				Data Record 8
0:13:08	0:12:47	0:00:21	21	ATC Call to Slow Down			
0:13:36	0:12:47	0:00:49	49			Argh!!!	
0:13:37	0:12:47	0:00:50	50		Ok, I have control.		VSS Disconnect
0:14:57				Script Birmingham			
0:16:08	0:16:08	0:00:00	0				Data Record 9
0:16:24	0:16:08	0:00:16	16	ATC Call to Turn			
0:17:00	0:16:08	0:00:52	52	ATC Call to Turn			
0:18:19	0:16:08	0:02:11	131			Emergency Trim!	
0:18:20	0:16:08	0:02:12	132		Ok, you have emergency trim.		
0:18:26	0:16:08	0:02:18	138				VSS Disconnect
0:18:27	0:16:08	0:02:19	139		Ok, I have control.		
0:19:29				Script Nagoya			
0:20:13	0:20:13	0:00:00	0				Data Record 10
0:20:22	0:20:13	0:00:09	9	ATC Call to Turn			
0:21:03	0:20:13	0:00:50	50	ATC Call to Turn			
0:21:32	0:20:13	0:01:19	79	ATC Advisory			
0:22:58	0:20:13	0:02:45	165	ATC Switch to			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Tower			
0:23:17	0:20:13	0:03:04	184	ATC Clearance to Land			
0:25:05	0:20:13	0:04:52	292			Emergency pitch trim.	
0:25:05	0:20:13	0:04:52	292		Emergency pitch trim selected.		
0:25:09	0:20:13	0:04:56	296			Going around.	
0:25:10	0:20:13	0:04:57	297		Ok, we're going around.		
0:25:16	0:20:13	0:05:03	303		You've got max power.		
0:25:17	0:20:13	0:05:04	304			Is it go around thrust please.	
0:25:18	0:20:13	0:05:05	305		It's go set, you've got go around thrust.		
0:25:21	0:20:13	0:05:08	308			Flaps ah flaps go around	
0:25:22	0:20:13	0:05:09	309		Flaps to go around		
0:25:23	0:20:13	0:05:10	310		Selected.	And gear up	
0:25:24	0:20:13	0:05:11	311		And gear coming up.		
0:25:29	0:20:13	0:05:16	316		Ok, I'll take it.		
0:25:31	0:20:13	0:05:18	318		I have Control.		VSS Disconnect
0:26:13				Script Charlotte			
0:26:45	0:26:45	0:00:00	0				Data Record 11
0:26:55	0:26:45	0:00:10	10	ATC Call to Turn			
0:27:27	0:26:45	0:00:42	42	ATC Call to Turn			
0:29:14	0:26:45	0:02:29	149	ATC Switch to Tower			
0:29:27	0:26:45	0:02:42	162	ATC Clearance to Land			
0:31:05	0:26:45	0:04:20	260		Ok, max power set.	We got a windshear, look at that a windshear.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:31:13	0:26:45	0:04:28	268			Call out altitude and trims.	
0:31:15	0:26:45	0:04:30	270		Ok, we're climbing.		
0:31:30	0:26:45	0:04:45	285		Ok, I have control.		VSS Disconnect
0:32:35				Script Shemya			
0:32:55	0:32:55	0:00:00	0				Data Record 12
0:33:39	0:32:55	0:00:44	44			.... So it's easier to read, kinda like...Whoa!	
0:33:41	0:32:55	0:00:46	46				VSS Disconnect
0:33:42	0:32:55	0:00:47	47		Ok, I have control.		
0:35:40				Surprise Birmingham			Data Record 14
0:36:59	0:36:59	0:00:00	0			Whoa, whoa what was that!	
0:37:02	0:36:59	0:00:03	3			Did you do something?	
0:37:07	0:36:59	0:00:08	8			Ahh, my pitch isn't working, emergency pitch!	
0:37:11	0:36:59	0:00:12	12		Emergency pitch, you've got it?		
0:37:13	0:36:59	0:00:14	14		Ok, I have control.		VSS Disconnect

19.3.5 Subject 5

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Toledo			
0:00:37	0:00:37	0:00:00	0				Data Record 5
0:00:49	0:00:37	0:00:12	12	ATC			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Contact Departure			
0:01:01	0:00:37	0:00:24	24	ATC Climb			
0:01:24	0:00:37	0:00:47	47	ATC Call to Turn			
0:01:34	0:00:37	0:00:57	57			Ok, altitude!	
0:01:35	0:00:37	0:00:58	58			You have it! You have it!	
0:01:36	0:00:37	0:00:59	59			My controls!	
0:01:57	0:00:37	0:01:20	80		All right. You ok over there?	(sigh) I'm ok.	
0:02:02	0:00:37	0:01:25	85		All right I'll take the airplane.		VSS Disconnect
0:03:04				Script Shemya			
0:03:35	0:03:35	0:00:00	0				Data Record 6
0:04:18	0:03:35	0:00:43	43			Should we release the autopilot?	
0:04:21	0:03:35	0:00:46	46		Say again?		
0:04:23	0:03:35	0:00:48	48			Autopilot disengaged! My controls.	
0:04:24	0:03:35	0:00:49	49				VSS Disconnect
0:04:25	0:03:35	0:00:50	50		All right, I have the airplane.		
0:07:39				Script Detroit			
0:08:08	0:08:08	0:00:00	0				Data Record 9
0:08:44	0:08:08	0:00:36	36	ATC Call to Slow Down			
0:09:25	0:08:08	0:01:17	77			What's going on here we're getting slow.	
0:09:32	0:08:08	0:01:24	84			Ouch!	
0:09:32	0:08:08	0:01:24	84	ATC Call to Turn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:09:42	0:08:08	0:01:34	94			Declaring an emergency!	
0:09:43	0:08:08	0:01:35	95		Ok, we will declare an emergency and you can let go of the stick.		
0:09:46	0:08:08	0:01:38	98				VSS Disconnect
0:09:47	0:08:08	0:01:39	99		I have the airplane.		
0:11:07				Script Nagoya			
0:11:53	0:11:53	0:00:00	0				Data Record 10
0:12:21	0:11:53	0:00:28	28	ATC Call to Turn			
0:13:06	0:11:53	0:01:13	73	ATC Call to Turn			
0:13:25	0:11:53	0:01:32	92	ATC Advisory			
0:14:44	0:11:53	0:02:51	171	ATC Switch to Tower			
0:15:00	0:11:53	0:03:07	187	ATC Clearance to Land			
0:16:34	0:11:53	0:04:41	281			I've got pitch trim or runaway or something is going on here, we have a problem!	
0:16:38	0:11:53	0:04:45	285			Missed approach, disengage pitch trim!	
0:16:45	0:11:53	0:04:52	292			That was it. We're going vertical.	
0:16:46	0:11:53	0:04:53	293		Just bank the airplane.	Ok	
0:16:47	0:11:53	0:04:54	294		I have the airplane.	Ok	VSS Disconnect
0:18:39				Script Birmingham			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:19:06	0:19:06	0:00:00	0				Data Record 11
0:19:33	0:19:06	0:00:27	27	ATC Call to Turn			
0:20:20	0:19:06	0:01:14	74	ATC Call to Turn			
0:20:50	0:19:06	0:01:44	104			Oh!	
0:21:30	0:19:06	0:02:24	144			Missed Approach!	
0:21:31	0:19:06	0:02:25	145				VSS Disconnect
0:21:32	0:19:06	0:02:26	146		I have the airplane.		
0:22:20				Script Charlotte			
0:23:09	0:23:09	0:00:00	0				Data Record 12
0:23:35	0:23:09	0:00:26	26	ATC Call to Turn			
0:23:49	0:23:09	0:00:40	40			Is that the stick shaker?	
0:23:53	0:23:09	0:00:44	44		It could be, or quite a bit of windshear here.		
0:24:17	0:23:09	0:01:08	68	ATC Call to Turn			
0:26:41	0:23:09	0:03:32	212	ATC Switch to Tower			
0:27:00	0:23:09	0:03:51	231	ATC Clearance to Land			
0:27:18	0:23:09	0:04:09	249			Airplane's going real funny here.	
0:28:16	0:23:09	0:05:07	307			Windshear! Windshear! Windshear! Missed approach! Max power, flaps down!	
0:28:20	0:23:09	0:05:11	311		Ok, max power set.		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:28:29	0:23:09	0:05:20	320			Positive rate, gear up.	
0:28:31	0:23:09	0:05:22	322		Gear coming up		
0:28:32	0:23:09	0:05:23	323			Flaps up.	
0:28:33	0:23:09	0:05:24	324		Sorry, a little slow with the flaps sir.		
0:28:35	0:23:09	0:05:26	326		Ok that's good. Push over a little bit, I'll take the airplane.		
0:28:37	0:23:09	0:05:28	328				VSS Disconnect
0:30:26							
0:30:32	0:30:32	0:00:00	0	Script Roselawn			
0:31:27	0:30:32	0:00:55	55	ATC Speed			Data Record 13
0:32:04	0:30:32	0:01:32	92	ATC Call to Turn			
0:32:47	0:30:32	0:02:15	135			I've got something going on with the controls here I think!	
0:32:54	0:30:32	0:02:22	142			I have it.	
0:33:00	0:30:32	0:02:28	148	ATC Call to Turn			
0:33:10	0:30:32	0:02:38	158			330. Think we should declare an emergency we have a flight control malfunction of some sort.	
0:33:15	0:30:32	0:02:43	163		We need to turn a bit here; I'll do that for you.		
0:33:41	0:30:32	0:03:09	189		Ok, we will stop it there, I have the airplane.		
0:33:42	0:30:32	0:03:10	190				VSS Disconnect
0:34:02	0:30:32	0:03:30	210		Are you having fun Yet?		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:34:03	0:30:32	0:03:31	211			Yea, I am having a blast, I could do this all day long, and this is really interesting.	
0:34:39				Script Pittsburgh			
0:35:00	0:35:00	0:00:00	0				Data Record 14
0:35:31	0:35:00	0:00:31	31	ATC Call to Turn			
0:36:21	0:35:00	0:01:21	81			I've got a problem with the rudder here! We're losing ....!	
0:36:32	0:35:00	0:01:32	92			We're losing it!!!!!	VSS Disconnect
0:36:33	0:35:00	0:01:33	93		I've got control.	Shit!!!	
0:36:39	0:35:00	0:01:39	99		Ok, very nice.	Jesus, that was fun. (Laughs)	
0:36:42	0:35:00	0:01:42	102		Felt real. Felt real didn't it.		
0:36:50	0:35:00	0:01:50	110	(Laughs)	(Laughs)	Holy shit that one must be scary in real life!	
0:35:52	0:35:00	0:00:52	52		Very good. (Laughs)		
0:37:57	0:37:57	0:00:00	0	Surprise Nagoya			Data Record 15
0:40:01	0:37:57	0:02:04	124			We've got a pitch control problem here.	
0:40:06	0:37:57	0:02:09	129			All full back.	
0:40:09	0:37:57	0:02:12	132			I'm, going to slow down a little here to se if that helps.	
0:40:15	0:37:57	0:02:18	138			I've got something wrong; hold full down the trim is not working.	
0:40:20	0:37:57	0:02:23	143			This...	
0:40:28	0:37:57	0:02:31	151				VSS Disconnect
0:40:29	0:37:57	0:02:32	152		Ok, I have it.		
0:40:30	0:37:57	0:02:33	153			Ok, you have control.	

19.3.6 Subject 6

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Shemya			
0:00:31	0:00:31	0:00:00	0				Data Record 5
0:01:26	0:00:31	0:00:55	55				VSS Disconnect
0:04:44				Script Nagoya			
0:06:21	0:06:21	0:00:00	0				Data Record 8
0:06:43	0:06:21	0:00:22	22	ATC Call to Turn			
0:08:25	0:06:21	0:02:04	124	ATC Call to Turn			
0:08:44	0:06:21	0:02:23	143	ATC Advisory			
0:10:14	0:06:21	0:03:53	233	ATC Switch to Tower			
0:10:31	0:06:21	0:04:10	250	ATC Clearance to Land			
0:11:59	0:06:21	0:05:38	338				VSS Disconnect
0:12:00	0:06:21	0:05:39	339		I have the airplane.		
0:12:47				Script Toledo			
0:14:06	0:14:06	0:00:00	0				Data Record 9
0:14:33	0:14:06	0:00:27	27	ATC Contact Departure			
0:14:47	0:14:06	0:00:41	41	ATC Climb			
0:15:01	0:14:06	0:00:55	55	ATC Call to Turn			
0:15:09	0:14:06	0:01:03	63			Watch your bank angle!	
0:15:14	0:14:06	0:01:08	68		You have the airplane. You have the airplane!!		
0:15:16	0:14:06	0:01:10	70			I have the airplane.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:15:43	0:14:06	0:01:37	97		Ok, let's press the green button.		
0:15:50	0:14:06	0:01:44	104				VSS Disconnect
0:01:51	0:14:06				I have the airplane.		
0:16:37				Script Charlotte			
0:17:09	0:17:09	0:00:00	0				Data Record 10
0:17:24	0:17:09	0:00:15	15	ATC Call to Turn			
0:18:08	0:17:09	0:00:59	59	ATC Call to Turn			
0:20:09	0:17:09	0:03:00	180	ATC Switch To Tower			
0:20:25	0:17:09	0:03:16	196	ATC Clearance to Land			
0:22:06	0:17:09	0:04:57	297			Windshear!	
0:22:25	0:17:09	0:05:16	316		All right. That's good. I have the airplane.		
0:22:26	0:17:09	0:05:17	317				VSS Disconnect
0:23:36				Script Detroit			
0:24:20	0:24:20	0:00:00	0				Data Record 11
0:24:47	0:24:20	0:00:27	27	ATC Call to Slow Down			
0:25:27	0:24:20	0:01:07	67	ATC Call to Turn			
0:25:35	0:24:20	0:01:15	75			Uhhh... Stand by.	
0:25:48	0:24:20	0:01:28	88			Ok (laughs)	
0:25:51	0:24:20	0:01:31	91		Ok, I have the airplane.		
0:25:52	0:24:20	0:01:32	92				VSS Disconnect
0:26:48				Script Pittsburgh			
0:27:28	0:27:28	0:00:00	0				Data Record 12

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:27:40	0:27:28	0:00:12	12	ATC Call to Turn			
0:28:34	0:27:28	0:01:06	66			The airplane…(laughs)	
0:28:35	0:27:28	0:01:07	67		I have the airplane.		VSS Disconnect
0:28:47	0:27:28	0:01:19	79		Not fun…scary.		
0:28:50	0:27:28	0:01:22	82		(Laughs)	My rudder stuck.	
0:28:51	0:27:28	0:01:23	83			Remind me never to go to Chicago.	
0:28:52	0:27:28	0:01:24	84	Laughs	Laughs		
0:29:44							Data Record 13
0:29:50	0:29:50	0:00:00	0			Are we doing the same thing or…	
0:29:51	0:29:50	0:00:01	1		I don't know?		
0:29:52	0:29:50	0:00:02	2	I'm sorry, let me read you the intro, I didn't give it to you yet, just keep flying on this heading.			
0:29:58	0:29:50	0:00:08	8	Script Birmingham			
0:30:27	0:29:50	0:00:37	37	ATC Call to Turn			
0:31:09	0:29:50	0:01:19	79	ATC Call to Turn			
0:32:48	0:29:50	0:02:58	178				VSS Disconnect
0:32:49	0:29:50	0:02:59	179		I have the airplane.		
0:39:10							
0:39:28	0:39:28	0:00:00	0	Script Roselawn			Data Record 15
0:39:52	0:39:28	0:00:24	24	ATC Speed			
0:40:32	0:39:28	0:01:04	64	ATC Call to Turn			
0:41:14	0:39:28	0:01:46	106				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:41:17	0:39:28	0:01:49	109		Ok, that's good; I'll take the airplane.		
0:42:51				Script Repeat Nagoya			
0:43:25	0:43:25	0:00:00	0				Data Record 16
0:43:42	0:43:25	0:00:17	17	ATC Call to Turn			
0:44:23	0:43:25	0:00:58	58	ATC Call to Turn			
0:46:11	0:43:25	0:02:46	166	ATC Switch to Tower			
0:46:28	0:43:25	0:03:03	183	ATC Clearance to Land			
0:48:12	0:43:25	0:04:47	287		I have the airplane.		VSS Disconnect
0:48:14	0:43:25	0:04:49	289			You have the airplane.	
0:49:32				Script Birmingham repeat			
0:50:05	0:50:05	0:00:00	0				Data Record 17
0:50:37	0:50:05	0:00:32	32	ATC Call to Turn			
0:51:22	0:50:05	0:01:17	77	ATC Call to Turn			
0:53:15	0:50:05	0:03:10	190				VSS Disconnect
0:53:16	0:50:05	0:03:11	191		I have the airplane.		
0:53:53	0:53:53	0:00:00	0	Surprise Pittsburgh			Data Record 18
0:54:35	0:53:53	0:00:42	42			Oh!	
0:54:39	0:53:53	0:00:46	46		I have the airplane.		VSS Disconnect

19.3.7 Subject 7

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Charlotte			
0:00:45	0:00:45	0:00:00	0				Data Record 1
0:01:02	0:00:45	0:00:17	17	ATC call to Turn			
0:01:57	0:00:45	0:01:12	72	ATC call to Turn			
0:03:52	0:00:45	0:03:07	187	ATC Switch to Tower			
0:04:06	0:00:45	0:03:21	201	ATC Clearance to Land			
0:04:52	0:00:45	0:04:07	247			Wuh Wuh Wuh..	
0:05:46	0:00:45	0:05:01	301			Windshear, Windshear.	
0:05:47	0:00:45	0:05:02	302			Flaps up, gear up.	
0:05:49	0:00:45	0:05:04	304		Ok, Flaps coming up, gear up.		
0:05:57	0:00:45	0:05:12	312		Power set at max.		
0:06:10	0:00:45	0:05:25	325		Watch your speed.		
0:06:20	0:00:45	0:05:35	335		Ok, scenario's over.		
0:06:22	0:00:45	0:05:37	337				VSS Disconnect
0:07:21				Script Pittsburgh			
0:07:43	0:07:43	0:00:00	0				Data Record 2
0:08:06	0:07:43	0:00:23	23	ATC Call to Turn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:09:04	0:07:43	0:01:21	81		Your altitude!	Yup.	
0:09:06	0:07:43	0:01:23	83		I have the airplane.		VSS Disconnect
0:09:48				Script Nagoya			
0:10:13	0:10:13	0:00:00	0				Data Record 3
0:10:40	0:10:13	0:00:27	27	ATC Call to Turn			
0:11:15	0:10:13	0:01:02	62	ATC Call to Turn			
0:11:35	0:10:13	0:01:22	82	ATC Advisory			
0:13:11	0:10:13	0:02:58	178	ATC Switch to Tower			
0:13:25	0:10:13	0:03:12	192	ATC Clearance to Land			
0:14:52	0:10:13	0:04:39	279			Argh!	
0:14:57	0:10:13	0:04:44	284			Well…uh ya. I fucked that one up. I see it now.	
0:15:00	0:10:13	0:04:47	287		Ok		VSS Disconnect
0:16:30				Script Roselawn			
0:16:48	0:16:48	0:00:00	0				Data Record 4
0:17:29	0:16:48	0:00:41	41	ATC Speed			
0:17:54	0:16:48	0:01:06	66	ATC Call to Turn			
0:18:55	0:16:48	0:02:07	127	ATC Call to Turn			
0:19:10	0:16:48	0:02:22	142			Lets do flaps.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:19:11	0:16:48	0:02:23	143		Flaps coming.		
0:19:23	0:16:48	0:02:35	155			Flaps up.	
0:19:25	0:16:48	0:02:37	157		Something Wrong Sir?		
0:19:28	0:16:48	0:02:40	160			Ya.	
0:19:31	0:16:48	0:02:43	163			It's like we needed an awful lot of power to hold altitude there.	
0:19:37	0:16:48	0:02:49	169		Why don't you try to slow to 150 on this heading?		
0:19:42	0:16:48	0:02:54	174		I'll give you flaps 20	Flaps 20.	
0:20:01	0:16:48	0:03:13	193	ATC Call to Turn			
0:20:55	0:16:48	0:04:07	247			What the hell!	
0:21:00	0:16:48	0:04:12	252			Well, is the autopilot off?	
0:21:02	0:16:48	0:04:14	254			Am I problem solving here?	
0:21:03	0:16:48	0:04:15	255		I guess so.		
0:21:05	0:16:48	0:04:17	257			Let's see, lets do flaps up.	
0:21:09	0:16:48	0:04:21	261		Flaps coming up.		
0:21:11	0:16:48	0:04:23	263			We've got a minimum speed without gear. We need to ask for that.	
0:21:16	0:16:48	0:04:28	268		Ok, that's the end thank you. I'll disengage.		
0:21:18	0:16:48	0:04:30	270				VSS Disconnect
0:22:43				Script Shemya			
0:23:12	0:23:12	0:00:00	0				Data Record 5
0:24:00	0:23:12	0:00:48	48			All right, so we're disengaging the autopilot.	
0:24:04	0:23:12	0:00:52	52				VSS

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Disconnect
0:24:05	0:23:12	0:00:53	53		All right, I have the airplane.		
0:26:17				Script Birmingham			
0:26:43	0:26:43	0:00:00	0				Data Record 7
0:27:01	0:26:43	0:00:18	18	ATC Call to Turn			
0:27:42	0:26:43	0:00:59	59	ATC Call to Turn			
0:29:19	0:26:43	0:02:36	156			Flaps up	
0:29:20	0:26:43	0:02:37	157		Flaps up		
0:29:27	0:26:43	0:02:44	164				VSS Disconnect
0:29:28	0:26:43	0:02:45	165		All right, that's it.		
0:30:13				Script Toledo			
0:30:57	0:30:57	0:00:00	0				Data Record 8
0:31:10	0:30:57	0:00:13	13	ATC Contact Departure			
0:31:25	0:30:57	0:00:28	28	ATC Climb			
0:31:44	0:30:57	0:00:47	47	ATC Call to Turn			
0:31:52	0:30:57	0:00:55	55			Ah, you're getting pretty steep there.	
0:31:54	0:30:57	0:00:57	57			And....	
0:31:56	0:30:57	0:00:59	59			What's happening?	
0:31:57	0:30:57	0:01:00	60		You've got it!		
0:31:58	0:30:57	0:01:01	61				VSS Disconnect
0:32:02	0:30:57	0:01:05	65			(Laughs)	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:32:03	0:30:57	0:01:06	66		Ok?		
0:32:45				Script Detroit			
0:33:07	0:33:07	0:00:00	0				Data Record 9
0:33:43	0:33:07	0:00:36	36	ATC Call to Slow Down			
0:34:06	0:33:07	0:00:59	59			Ahh. You've got to push stick or we've got to get rid of that stick shaker.	
0:34:08	0:33:07	0:01:01	61		Ok.		
0:34:15	0:33:07	0:01:08	68			Eh.	
0:34:23	0:33:07	0:01:16	76			Eh. You've got any good ideas here.	
0:34:26	0:33:07	0:01:19	79		I don't know.		
0:34:38	0:33:07	0:01:31	91		All right.... good.	We need to make a call too.	
0:34:41	0:33:07	0:01:34	94				VSS Disconnect

19.3.8 Subject 8

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Shemya			
0:00:17	0:00:17	0:00:00	0				Data Record 5
0:01:01	0:00:17	0:00:44	44			Wow	
0:01:02	0:00:17	0:00:45	45			Wow	VSS Disconnect
0:01:03	0:00:17	0:00:46	46		I have control		
0:01:04	0:00:17	0:00:47	47			All right, your airplane.	
0:03:15				Script Roselawn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:04:14	0:04:14	0:00:00	0				Data Record 7
0:04:46	0:04:14	0:00:32	32	ATC Speed			
0:05:30	0:04:14	0:01:16	76			300 on the heading.... Oh...Disconnect!	
0:05:45	0:04:14	0:01:31	91			What a commanding roll.	
0:05:48	0:04:14	0:01:34	94	ATC call to Turn			
0:05:55	0:04:14	0:01:41	101				VSS Disconnect
0:05:55	0:04:14	0:01:41	101		Ok, I'm going to take it. I have control.	Ok	
0:07:05				Script Nagoya			
0:07:58	0:07:58	0:00:00	0				Data Record 8
0:08:07	0:07:58	0:00:09	9	ATC call to Turn			
0:08:40	0:07:58	0:00:42	42	ATC call to Turn			
0:08:55	0:07:58	0:00:57	57	ATC Advisory			
0:10:44	0:07:58	0:02:46	166	ATC Switch to Tower			
0:10:59	0:07:58	0:03:01	181	ATC Clearance to Land			
0:12:22	0:07:58	0:04:24	264			I've got a runaway trim.	
0:12:23	0:07:58	0:04:25	265			Emergency trim, Emergency Trim!	
0:12:24	0:07:58	0:04:26	266		Ok, emergency trim selected.		
0:12:29	0:07:58	0:04:31	271			All right, let's turn around.	
0:12:38	0:07:58	0:04:40	280			And missed approach.	VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:12:39	0:07:58	0:04:41	281		All right, I have control.	All right.	
0:12:51	0:07:58	0:04:53	293			Did I goof it up?	
0:12:52	0:07:58	0:04:54	294		Nope.		
0:12:56	0:07:58	0:04:58	298		No you did not.		
0:13:56				Script Pittsburgh			
0:14:51	0:14:51	0:00:00	0				Data Record 9
0:15:03	0:14:51	0:00:12	12	ATC Call to Turn			
0:15:48	0:14:51	0:00:57	57			All right, missed approach.	
0:15:50	0:14:51	0:00:59	59			Oh!	
0:15:52	0:14:51	0:01:01	61		Ok, I have control.		VSS Disconnect
0:16:02	0:14:51	0:01:11	71			(Relief) That was a fun one huh.	
0:16:04	0:14:51	0:01:13	73			Ah ya.	
0:19:17				Script Charlotte			
0:20:00	0:20:00	0:00:00	0				Data Record 10
0:20:08	0:20:00	0:00:08	8	ATC Call to Turn			
0:20:42	0:20:00	0:00:42	42	ATC Call to Turn			
0:22:50	0:20:00	0:02:50	170	ATC Switch to Tower			
0:23:16	0:20:00	0:03:16	196	ATC Clearance to Land			
0:24:16	0:20:00	0:04:16	256			Oh. We have a windshear, a	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
						windshear!	
0:24:17	0:20:00	0:04:17	257			All right...uh.... escape, escape!	
0:24:20	0:20:00	0:04:20	260		Ok, Max power.		
0:24:23	0:20:00	0:04:23	263			All right, flaps down and positive gear up.	
0:24:24	0:20:00	0:04:24	264		ok, gear up.		
0:24:30	0:20:00	0:04:30	270			How am i going, How am I doing!	
0:24:31	0:20:00	0:04:31	271		You're at a 1000 AGL, climbing 2000 looking good, airspeed's about 125.		
0:24:40	0:20:00	0:04:40	280				VSS Disconnect
0:24:41	0:20:00	0:04:41	281		Ok, I have control.		
0:26:06				Script Detroit			
0:26:42	0:26:42	0:00:00	0				Data Record 11
0:27:16	0:26:42	0:00:34	34	ATC Call to Slow Down			
0:27:58	0:26:42	0:01:16	76			All right!	
0:28:51	0:26:42	0:02:09	129			That's not going to work.	
0:28:12	0:26:42	0:01:30	90			There we go.	
0:28:24	0:26:42	0:01:42	102		That was fun huh.	Ya.	
0:28:25	0:26:42	0:01:43	103		Ok, I have control.		
0:28:26	0:26:42	0:01:44	104				VSS Disconnect
0:29:43				Script Toledo			
0:30:24	0:30:24	0:00:00	0				Data Record 12
0:30:35	0:30:24	0:00:11	11	ATC Contact Departure			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:30:51	0:30:24	0:00:27	27	ATC Climb			
0:31:11	0:30:24	0:00:47	47	ATC Call to Turn			
0:31:19	0:30:24	0:00:55	55			Ohhhhhh!!!	
0:31:20	0:30:24	0:00:56	56		You got it?		
0:31:21	0:30:24	0:00:57	57			Yup.	
0:31:22	0:30:24	0:00:58	58			Far back, Far back.	
0:31:26	0:30:24	0:01:02	62			Turning…ok.	
0:31:30	0:30:24	0:01:06	66			Help me out here. Help me out here	
0:31:31	0:30:24	0:01:07	67		You got it?		
0:31:42	0:30:24	0:01:18	78		Ok, I have control.		
0:31:43	0:30:24	0:01:19	79				VSS Disconnect
0:33:02				Script Birmingham			
0:33:33	0:33:33	0:00:00	0				Data Record 13
0:33:47	0:33:33	0:00:14	14	ATC Call to Turn			
0:34:27	0:33:33	0:00:54	54	ATC Call to Turn			
0:35:32	0:33:33	0:01:59	119			Uh!	
0:35:41	0:33:33	0:02:08	128		Watch out your going high.		
0:35:42	0:33:33	0:02:09	129			All right, runaway trim.	
0:35:45	0:33:33	0:02:12	132		Well, ok. Um…..		
0:35:46	0:33:33	0:02:13	133			I don't know what that was.	
0:35:57	0:33:33	0:02:24	144		Ok, You got it		
0:35:58	0:33:33	0:02:25	145				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:35:59	0:33:33	0:02:26	146		I have control.	You have the airplane.	
0:36:11	0:36:11	0:00:00	0	Surprise Pittsburgh			Data Record 14
0:37:05	0:36:11	0:00:54	54			Ah!!	
0:37:06	0:36:11	0:00:55	55				VSS Disconnect
0:37:07	0:36:11	0:00:56	56		All right, I have control.		
0:37:09	0:36:11	0:00:58	58			What was that?	

19.4 AERO/ UPSET GROUP

19.4.1 Subject 1

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(seconds)				
0:00:00			Script Pittsburgh			
0:00:30	0:00:00	0				Data Record 5
0:00:41	0:00:11	11	ATC Call to Turn			
0:01:49	0:01:19	79			Can you help me out on the aileron?	
0:01:52	0:01:22	82		I'm pushing on; and the rudder, I'm pushing on it.		
0:01:55	0:01:25	85		I'm pushing on it, pushing on it.		
0:02:00	0:01:30	90			Argh, flight idle.	
0:02:02	0:01:32	92		Flight idle.		
0:02:03	0:01:33	93		Ok, and I have control.		VSS Disconnect
0:03:18			Script Nagoya			
0:04:13	0:00:00	0				Data Record 6

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:04:23	0:00:10	10	ATC Call to Turn			
0:05:11	0:00:58	58	ATC Call to Turn			
0:05:34	0:01:21	81	ATC Advisory			
0:06:54	0:02:41	161	ATC Switch to Tower			
0:07:15	0:03:02	182	ATC Clearance to Land			
0:09:10	0:04:57	297		Watch, your nose up there.		
0:09:11	0:04:58	298			All right, I'm going to get the nose down if I can.	
0:09:12	0:04:59	299		Watch your nose up.		
0:09:13	0:05:00	300			Fuck!	
0:09:14	0:05:01	301		Watch your speed.		
0:09:17	0:05:04	304				VSS Disconnect
0:09:18	0:05:05	305		Ok I have control.		
0:11:02			Script Roselawn			
0:11:30	0:00:00	0				Data Record 7
0:12:10	0:00:40	40	ATC Speed			
0:13:01	0:01:31	91	ATC Call to Turn			
0:13:26	0:01:56	116			Oh man, help me on the aileron please.	
0:13:27	0:01:57	117		Ok.		
0:13:43	0:02:13	133		Watch you altitude you going to idle here.		
0:13:46	0:02:16	136		Watch your altitude.		
0:14:04	0:02:34	154		Ok, let's knock that off here.		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:14:06	0:02:36	156				VSS Disconnect
0:14:07	0:02:37	157		Ok, I have control.		
0:14:56			Script Shemya			
0:16:13	0:00:00	0				Data Record 8
0:17:01	0:00:48	48				VSS Disconnect
0:17:10	0:00:57	57		Did you take the autopilot off there?		
0:17:12	0:00:59	59			Yea, I took it off.	
0:20:03			Script Birmingham			
0:21:06	0:00:00	0				Data Record 10
0:21:25	0:00:19	19	ATC Call to Turn			
0:22:04	0:00:58	58	ATC Call to Turn			
0:23:41	0:02:35	155			Whoa!	
0:23:45	0:02:39	159			Not good.	
0:23:54	0:02:48	168		Watch your altitude.		
0:23:55	0:02:49	169		Your climbing 2000.		
0:23:57	0:02:51	171				VSS Disconnect
0:23:58	0:02:52	172		Ok, I have control.		
0:25:04			Script Toledo			
0:25:39	0:00:00	0.00				Data Record 11
0:25:51	0:00:12	12.00	ATC Contact Departure			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:26:06	0:00:27	27.00	ATC Climb			
0:26:26	0:00:47	47.00	ATC Call to Turn			
0:26:34	0:00:55	55.00			Watch your bank. Watch your bank!	
0:26:37	0:00:58	58.00			Watch your bank angle!	
0:26:39	0:01:00	60.00		You got it?	I have it.	
0:26:43	0:01:04	64.00			A-n-d.... reduce trust a little please.	
0:26:58	0:01:19	79.00			I wanna check the engine. Do we have an engine out? And reduce thrust a little please.	
0:27:03	0:01:24	84.00			Keeping in around 220.	
0:27:07	0:01:28	88.00		Ok, I have control.		
0:27:09	0:01:30	90.00			You have the controls.	VSS Disconnect
0:28:20			Script Detroit			
0:28:57	0:00:00	0.00				Data Record 12
0:29:35	0:00:38	38.00	ATC Call to Slow down			
0:30:34	0:01:37	97.00			Ok, that apparently not happening.	
0:30:46	0:01:49	109.00			There we go.	
0:30:53	0:01:56	116.00			Reduce thrust.	
0:30:54	0:01:57	117.00		Watch your altitude there.	Reduce thrust a little please.	
0:30:55	0:01:58	118.00		Reduced		
0:31:02	0:02:05	125.00		Ok	And...increase in a little for a climb	
0:31:14	0:02:17	137.00		Ok that's enough.		
0:31:15	0:02:18	138.00				VSS Disconnect
0:32:28			Script Charlotte			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:33:10	0:00:00	0.00				Data Record 13
0:33:34	0:00:24	24.00	ATC Call to Turn			
0:34:26	0:01:16	76.00	ATC Call to Turn			
0:35:30	0:02:20	140.00	ATC Switch to Tower			
0:36:48	0:03:38	218.00	ATC Clearance to Land			
0:38:56	0:05:46	346.00		Whoa, look at the Windshear! We have a windshear!		
0:39:00	0:05:50	350.00			Set max thrust!	
0:39:01	0:05:51	351.00		Max thrust.		
0:39:09	0:05:59	359.00			I'm not sure were the shaker is on this thing.	
0:39:12	0:06:02	362.00		Well it's shaken now. That's for sure.		
0:39:21	0:06:11	371.00		Are you going to put the gear up or anything?		
0:39:22	0:06:12	372.00			Ah. Not till we get out of it.	
0:39:25	0:06:15	375.00			Get the configurations not please.	
0:39:28	0:06:18	378.00		Ok, let's knock that one off.		
0:39:29	0:06:19	379.00		I have control.		VSS Disconnect
0:39:47	0:00:00	0.00	Surprise Birmingham			Data Record 14
0:40:30	0:00:43	43.00			Uh oh.	
0:40:32	0:00:45	45.00			Is that you?	
0:40:41	0:00:54	54.00		Is what me? What's going on?		
0:40:47	0:01:00	60.00				VSS Disconnect

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:40:48	0:01:01	61.00		Ok I have control.		

19.4.2 Subject 2

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(seconds)				
0:00:00			Script Pittsburgh			
0:00:22	0:00:00	0				Data Record 1
0:00:44	0:00:22	22	ATC Call to Turn			
0:01:50	0:01:28	88			Whoa! What's that?	
0:01:52	0:01:30	90			Wake turbulence. Full Power.	
0:01:54	0:01:32	92		Ok, we have full power.		
0:01:57	0:01:35	95			We have plenty of speed.	
0:02:07	0:01:45	105			I need to tell ATC that we are going around and climbing.	
0:02:10	0:01:48	108		Ok.	We have some lack of altitude.	
0:02:12	0:01:50	110		Ok, I'll go ahead and take it.		
0:02:13	0:01:51	111				VSS Disconnect
0:03:12			Script Roselawn			
0:03:32	0:00:00	0				Data Record 2
0:04:09	0:00:37	37	ATC Speed			
0:04:27	0:00:55	55			Whoa!	
0:04:29	0:00:57	57			That's full power!	
0:04:30	0:00:58	58		Ok full power, you got it.		
0:04:33	0:01:01	61		You've got full power.		
0:04:37	0:01:05	65	ATC Call to			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
			Turn			
0:04:42	0:01:10	70			What's going on?	
0:04:43	0:01:11	71			You'd better tell them that we are having problems here.	
0:04:52	0:01:20	80	ATC Emergency	Yea.	Oh yea.	
0:04:53	0:01:21	81		Can you turn?		
0:04:57	0:01:25	85			What was the heading you want?	
0:05:01	0:01:29	89		100		
0:05:05	0:01:33	93		What seems to be going on? What is the problem?		
0:05:10	0:01:38	98			Everything seems to be normal now.	
0:05:12	0:01:40	100		Ok, let's see if we can continue the turn.		
0:05:24	0:01:52	112		Ok, let's knock it off.		
0:05:25	0:01:53	113		I have control.		VSS Disconnect
0:06:10			Script Charlotte			
0:06:37	0:00:00	0				Data Record 3
0:06:59	0:00:22	22	ATC Call to Turn			
0:07:43	0:01:06	66	ATC Call to Turn			
0:09:36	0:02:59	179	ATC Switch to Tower			
0:09:44	0:03:07	187	ATC Clearance to Land			
0:10:16	0:03:39	219			Big updraft.	
0:10:48	0:04:11	251			We are going high here.	
0:11:46	0:05:09	309			Whoa we have a windshear!	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:11:48	0:05:11	311			Ok, I have the power.	
0:11:49	0:05:12	312			Full power.	
0:11:50	0:05:13	313			Full power.	
0:11:53	0:05:16	316			Full power.	
0:11:58	0:05:21	321		You've got full power.		
0:12:05	0:05:28	328		You've got a good climb rate there.		
0:12:07	0:05:30	330			Accelerating?	
0:12:08	0:05:31	331		Yep.		
0:12:14	0:05:37	337		Ok there's a 1000 AGL, Ok good job.		
0:12:17	0:05:40	340		I have control.		VSS Disconnect
0:12:54			Script Birmingham			
0:13:19	0:00:00	0				Data Record 4
0:13:40	0:00:21	21	ATC Call to Turn			
0:14:18	0:00:59	59	ATC Call to Turn			
0:15:51	0:02:32	152		Whoa!		
0:15:57	0:02:38	158		Ok, were going around.	Going around!	
0:16:00	0:02:41	161		Watch you nose attitude, watch you nose attitude.		
0:16:03	0:02:44	164				VSS Disconnect
0:16:04	0:02:45	165		Whoa, ok we tripped it.		
0:16:49			Script Nagoya			
0:17:09	0:00:00	0				Data Record 5

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:17:27	0:00:18	18	ATC Call to Turn			
0:18:08	0:00:59	59	ATC Call to Turn			
0:18:30	0:01:21	81	ATC Advisory			
0:20:03	0:02:54	174	ATC Switch to Tower			
0:20:15	0:03:06	186	ATC Clearance to Land			
0:22:02	0:04:53	293			Let's go around.	
0:22:03	0:04:54	294		Ok let's go around.		
0:22:05	0:04:56	296			Runaway trim, Emergency trim!	
0:22:06	0:04:57	297		Ok we got emergency trim.		
0:22:08	0:04:59	299		Go ahead and use it if you…want.		
0:22:13	0:05:04	304		Got max power.		
0:22:24	0:05:15	315		Watch your speed. We're still slowing.		
0:22:30	0:05:21	321			Accelerating.	
0:22:36	0:05:27	327			And landing gear up.	
0:22:37	0:05:28	328		Gear up.		
0:22:42	0:05:33	333			And flaps up.	
0:22:43	0:05:34	334		And there up.		
0:22:48	0:05:39	339		All right, still hold forward force.		
0:22:52	0:05:43	343		Got to get the trim down.		
0:22:55	0:05:46	346			That's pretty much even now.	
0:22:56	0:05:47	347		Ok that's enough.		
0:22:57	0:05:48	348		I have control.		
0:22:58	0:05:49	349				VSS Disconnect
0:23:47			Script Detroit			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:24:39	0:00:00	0				Data Record 7
0:25:12	0:00:33	33	ATC Call to Slow down			
0:25:29	0:00:50	50			Ok, give me full power.	
0:25:30	0:00:51	51		Ok, you got it.		
0:25:42	0:01:03	63		You've got plenty of speed.		
0:25:55	0:01:16	76			I must have a load of ice on this thing.	
0:25:56	0:01:17	77		Ya, on one of the wings.		
0:26:01	0:01:22	82		Watch your nose attitude!	Gear and flaps up.	
0:26:03	0:01:24	84		Gear and flaps are up.		
0:26:05	0:01:26	86	ATC Call to Turn			
0:26:08	0:01:29	89			Ok, were declaring an emergency here, we have some definite problems here.	
0:26:13	0:01:34	94			Hey can you level off.	
0:26:16	0:01:37	97		Ok.	Bring the power back a little bit.	
0:26:29	0:01:50	110		Ok I have control.		VSS Disconnect
0:27:02			Script Shemya			
0:27:31	0:00:00	0				Data Record 8
0:28:20	0:00:49	49			What's the autopilot doing? Holy smokes!	
0:28:24	0:00:53	53			My aircraft.	VSS Disconnect
0:28:25	0:00:54	54			Whoa!	
0:30:09			Script Toledo			
0:30:32	0:00:00	0				Data Record 10
0:30:57	0:00:25	25	ATC Contact			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
			Departure			
0:31:20	0:00:48	48	ATC Climb			
0:31:28	0:00:56	56			We're not climbing!	
0:31:29	0:00:57	57			Captain, we're rolling!	
0:31:31	0:00:59	59		You got it?		
0:31:32	0:01:00	60			Yup	
0:31:33	0:01:01	61			Full power.	
0:31:46	0:01:14	74		Ok		
0:31:47	0:01:15	75		I have control, good job.		VSS Disconnect

19.4.3 Subject 3

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(seconds)				
0:00:00			Script Detroit			
0:01:10	0:00:00	0				Data Record 4
0:02:08	0:00:58	58	ATC Call to Slow Down			
0:02:59	0:01:49	109			Whoa, what do we got here!	VSS Disconnect
0:03:00	0:01:50	110		Ok, I have controls.		
0:03:50			Script Toledo			
0:05:07	0:00:00	0				Data Record 5
0:05:29	0:00:22	22	ATC Contact Departure			
0:05:41	0:00:34	34	ATC Climb			
0:05:55	0:00:48	48	ATC Call to			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
			Turn			
0:06:08	0:01:01	61		You got it?		VSS Disconnect
0:06:09	0:01:02	62			All right, my controls.	
0:06:10	0:01:03	63		I have control.		
0:07:10			Script Birmingham			
0:08:51	0:00:00	0				Data Record 6
0:09:28	0:00:37	37	ATC Call to Turn			
0:10:06	0:01:15	75	ATC Call to Turn			
0:11:33	0:02:42	162			There's the localizer	
0:11:34	0:02:43	163		Ok it's alive.		
0:11:35	0:02:44	164			It's set...Whoa!	
0:11:39	0:02:48	168			Oh!	
0:11:40	0:02:49	169		Ok, I have control.	All right.	
0:11:41	0:02:50	170				VSS Disconnect
0:12:31			Script Shemya			
0:14:01	0:00:00	0				Data Record 7
0:14:56	0:00:55	55		What was that?	All right.	
0:14:57	0:00:56	56			Do you want me to disconnect?	
0:14:58	0:00:57	57		I don't know. it's up to you.	I was just wondering is that the autopilot doing that?	
0:15:00	0:00:59	59			All right, well I don't know but I just disconnected.	
0:15:05	0:01:04	64			I didn't know if that was intentional or not.	
0:15:08	0:01:07	67			I just wanted to disconnect it. I tend to do that with the	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
					fist sign of ugly autopilot.	
0:15:35	0:01:34	94		All right, I have control.		VSS Disconnect
0:17:39			Script Roselawn			
0:20:31	0:00:00	0				Data Record 10
0:21:15	0:00:44	44	ATC Speed			
0:21:41	0:01:10	70			All right!	
0:21:45	0:01:14	74	ATC Call to Turn			
0:21:48	0:01:17	77			All right, let's just declare an emergency on the last roll so we can get priority…or should we continue the experiment?	
0:21:53	0:01:22	82		Well, let's see if you can turn.		
0:21:54	0:01:23	83			Ok.	
0:21:56	0:01:25	85			What's going on here?	
0:22:09	0:01:38	98			What was the altitude you assigned? Argh!	
0:22:11	0:01:40	100	5000			
0:22:15	0:01:44	104		Ok I have control.	Ah!	VSS Disconnect
0:23:25			Script Nagoya			
0:24:44	0:00:00	0				Data Record 11
0:25:01	0:00:17	17	ATC Call to Turn			
0:25:44	0:01:00	60	ATC Call to Turn			
0:26:02	0:01:18	78	ATC Advisory			
0:27:48	0:03:04	184	ATC Switch to Tower			

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:28:22	0:03:38	218	ATC Clearance to Land			
0:29:33	0:04:49	289			I'm starting to have to push, something's up.	
0:29:46	0:05:02	302			Ah, I can't push at all! I lost the glide slope.	
0:29:51	0:05:07	307		What, What's going on?		
0:29:52	0:05:08	308			I don't know but when I let go it just wants to pitch up full scale.	
0:29:59	0:05:15	315			I seems like we got a…	
0:30:00	0:05:16	316		Ok, I have control.		VSS Disconnect
0:30:05	0:05:21	321			I'm not quite sure what would do that. Unless, we had an elevator stall or something.	
0:30:11	0:05:27	327		Ok.	Was that part of the game?	
0:30:13	0:05:29	329		That was the upset definitely. We will talk to you about what it was later.		
0:30:31	0:05:47	347			I haven't seen that scenario before to tell you the truth.	
0:30:41	0:05:57	357			The only thing I can guess is that it's an inadvertent spoiler or something.	
0:31:41			Script Pittsburgh			
0:32:15	0:00:00	0				Data Record 12
0:32:36	0:00:21	21	ATC Call to Turn			
0:33:25	0:01:10	70			Argh!	
0:33:26	0:01:11	71		All right I have control.		
0:33:27	0:01:12	72				VSS Disconnect
0:33:28	0:01:13	73			I was pressing on the rudder and I felt nothing.	
0:33:38	0:01:23	83			I tried to press on it and it felt like a hard over or	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
					something.	
0:35:42			Script Charlotte			
0:36:05	0:00:00	0				Data Record 13
0:36:26	0:00:21	21	ATC Call to Turn			
0:37:08	0:01:03	63	ATC Call to Turn			
0:39:17	0:03:12	192	ATC Switch to Tower			
0:39:33	0:03:28	208	ATC Clearance to Land			
0:40:37	0:04:32	272		We're going a little low there.		
0:40:44	0:04:39	279		Now were going a little high.		
0:40:46	0:04:41	281			I think there might be a little of a shear out here.	
0:40:49	0:04:44	284			Oh ya, definitely a shear.	
0:40:57	0:04:52	292			I've might have gone around already in the real world.	
0:41:00	0:04:55	295		Ah, don't worry. We can make it.		
0:41:07	0:05:02	302		Watch you glide slope there.		
0:41:12	0:05:07	307			Ah, I'm rolling over, great!	
0:41:15	0:05:10	310			There's a stick shaker!	
0:41:16	0:05:11	311		Windshear!		
0:41:17	0:05:12	312		Power Set	Max Power!	
0:41:39	0:05:34	334			I'm gonna fly right at stick shaker here.	
0:41:50	0:05:45	345		Ok, it looks like we are descending here. 600 AGL	Yea	
0:41:54	0:05:49	349		Gears up.	All right, gears up!	
0:41:56	0:05:51	351			Flaps up!	

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:41:57	0:05:52	352		Flaps up.		
0:41:58	0:05:53	353		Max power.		
0:42:21	0:06:16	376		Ok, lets knock it off. I will take it.		
0:42:24	0:06:19	379		I have control.		VSS Disconnect
0:55:56			Script Toledo 2nd attempt			
0:56:33	0:00:00	0				Data Record 14
0:56:53	0:00:20	20	ATC Contact Departure			
0:57:06	0:00:33	33	ATC Climb			
0:57:26	0:00:53	53	ATC Call to Turn			
0:57:37	0:01:04	64			My controls!	
0:57:40	0:01:07	67		You got it?	I got it.	
0:57:41	0:01:08	68		You got it?		
0:58:06	0:01:33	93		Ok, I'll take control.		
0:58:08	0:01:35	95		I have control.		VSS Disconnect
0:52:06			Script Detroit 2nd Attempt			
0:53:05	0:00:00	0				Data Record 15
0:53:49	0:00:44	44	ATC Call to Slow Down			
0:54:20	0:01:15	75	ATC Call to Turn			
0:54:22	0:01:17	77			Whoa!	
0:54:27	0:01:22	82		Veridian 102 has some problems here, What's going here on?		

Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:54:28	0:01:23	83			All right, well it looks like a lose of elevator or something like that.... or actually a loss of aileron.	
0:54:33	0:01:28	88			Should be nice and easy on the rudder.	
0:54:48	0:01:43	103			I'll get some altitude back here.	
0:54:54	0:01:49	109			It feels like we just lost the aileron.	
0:54:59	0:01:54	114		Are you using rudder to help you out there?		
0:55:00	0:01:55	115		Ok, I have control.		
0:55:01	0:01:56	116			You have controls.	
0:55:03	0:01:58	118				VSS Disconnect
0:56:18	0:00:00	0	Surprise Nagoya			Data Record 16
0:57:29	0:01:11	71			Argh! It just got away.	
0:57:34	0:01:16	76			Is it suppose to be doing that?	
0:57:36	0:01:18	78		I don't know what do you got?		
0:57:38	0:01:20	80			Do you wanna a.... well its pitching up slowly.	
0:57:45	0:01:27	87			It's starting to pitch up quite a bit.	
0:57:48	0:01:30	90			Can I let go?	
0:57:49	0:01:31	91				VSS Disconnect
0:57:50	0:01:32	92		Ok, I have control.		
0:57:52	0:01:34	94			I don't know why it did that.	
0:57:53	0:01:35	95		That was called a surprise scenario.		

19.4.4 Subject 4

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Nagoya			
0:01:06	0:01:06	0:00:00	0				Data Record 5
0:01:17	0:01:06	0:00:11	11	ATC Call to Turn			
0:01:49	0:01:06	0:00:43	43	ATC Call to Turn			
0:02:09	0:01:06	0:01:03	63	ATC Advisory			
0:03:45	0:01:06	0:02:39	159	ATC Switch to Tower			
0:04:09	0:01:06	0:03:03	183	ATC Clearance to Land			
0:06:13	0:01:06	0:05:07	307		Watch, you're going high.		
0:06:15	0:01:06	0:05:09	309		Watch your speed.		
0:06:29	0:01:06	0:05:23	323				VSS Disconnect
0:06:30	0:01:06	0:05:24	324		Ok, I have control.		
0:07:29				Script Birmingham			
0:08:06	0:08:06	0:00:00	0				Data Record 6
0:08:19	0:08:06	0:00:13	13	ATC Call to Turn			
0:09:07	0:08:06	0:01:01	61	ATC Call to Turn			
0:10:18	0:08:06	0:02:12	132			Whoa!	
0:10:29	0:08:06	0:02:23	143			Damn!	
0:10:31	0:08:06	0:02:25	145				VSS Disconnect
0:10:32	0:08:06	0:02:26	146		Ok, I have control.		
0:12:00				Script Charlotte			
0:12:41	0:12:41	0:00:00	0				Data Record 7

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:12:51	0:12:41	0:00:10	10	ATC Call to Turn			
0:13:23	0:12:41	0:00:42	42	ATC Call to Turn			
0:15:11	0:12:41	0:02:30	150	ATC Switch to Tower			
0:15:30	0:12:41	0:02:49	169	ATC Clearance to Land			
0:18:01	0:12:41	0:05:20	320			We have a windshear, a windshear.	
0:18:05	0:12:41	0:05:24	324			Set thrust, flaps 8	
0:18:07	0:12:41	0:05:26	326		Max power.		
0:18:08	0:12:41	0:05:27	327		Flaps what?		
0:18:09	0:12:41	0:05:28	328			Set thrust, flaps 8	
0:18:11	0:12:41	0:05:30	330		Flaps eight.		
0:18:12	0:12:41	0:05:31	331		Max power set.	Max power.	
0:18:25	0:12:41	0:05:44	344		Ok, speed.		
0:18:30	0:12:41	0:05:49	349		We're sinking, we're 500 AGL.		
0:18:37	0:12:41	0:05:56	356		Still sinking, were 350 AGL.		
0:18:40	0:12:41	0:05:59	359		We've got max power set.		
0:18:42	0:12:41	0:06:01	361		Speed's 160		
0:18:48	0:12:41	0:06:07	367			Gear up.	
0:18:49	0:12:41	0:06:08	368		Selected up.		
0:18:54	0:12:41	0:06:13	373		Speed's building.		
0:19:01	0:12:41	0:06:20	380		There we go now were climbing.		
0:19:06	0:12:41	0:06:25	385		400 AGL and climbing.		
0:19:13	0:12:41	0:06:32	392		Ok, sounds good, we'll knock that one off then.		
0:19:15	0:12:41	0:06:34	394				VSS Disconnect
0:19:21	0:12:41	0:06:40	400		I have control.		

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:20:21				Script Roselawn			
0:21:03	0:21:03	0:00:00	0				Data Record 8
0:21:39	0:21:03	0:00:36	36	ATC Speed			
0:21:56	0:21:03	0:00:53	53			Argh!	
0:22:01	0:21:03	0:00:58	58			Ah Shit!	
0:22:05	0:21:03	0:01:02	62				
0:22:06	0:21:03	0:01:03	63		Ok, I have control		VSS Disconnect
0:23:13				Script Pittsburgh			
0:24:13	0:24:13	0:00:00	0				Data Record 9
0:24:23	0:24:13	0:00:10	10	ATC Call to Turn			
0:25:13	0:24:13	0:01:00	60			Whoa!	
0:25:24	0:24:13	0:01:11	71		Ok, I have control.		VSS Disconnect
0:26:50				Script Toledo			
0:27:28	0:27:28	0:00:00	0				Data Record 10
0:27:38	0:27:28	0:00:10	10	ATC Contact Departure			
0:27:57	0:27:28	0:00:29	29	ATC Climb			
0:28:15	0:27:28	0:00:47	47	ATC Call to Turn			
0:28:23	0:27:28	0:00:55	55			Watch you bank. Check your bank!	
0:28:26	0:27:28	0:00:58	58		You got it?		
0:28:31	0:27:28	0:01:03	63			Add Thrust!	
0:28:35	0:27:28	0:01:07	67		Ok, we got thrust added.		
0:28:46	0:27:28	0:01:18	78		Ok, I'll go ahead and take it.		
0:28:47	0:27:28	0:01:19	79		I have Control.		VSS

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Disconnect
0:29:36				Script Shemya			
0:30:47	0:30:47	0:00:00	0				Data Record 11
0:31:37	0:30:47	0:00:50	50			Autopilot disconnects.	
0:31:38	0:30:47	0:00:51	51				VSS Disconnect
0:31:39	0:30:47	0:00:52	52		Ok, I have control.		
0:34:02				Script Detroit			
0:35:02	0:35:02	0:00:00	0				Data Record 13
0:35:27	0:35:02	0:00:25	25	ATC Call to Slow Down			
0:36:00	0:35:02	0:00:58	58			Whoa!	
0:36:08	0:35:02	0:01:06	66			Ah Shit!	
0:36:34	0:35:02	0:01:32	92		Ok, we're climbing back up were supposed to be at five.		
0:36:37	0:35:02	0:01:35	95			Oh, I don't care at this point. (laughs)	
0:36:40	0:35:02	0:01:38	98		Ok, I have control.		VSS Disconnect
0:37:03	0:37:03	0:00:00	0	Surprise Pittsburgh			Data Record 14
0:38:02	0:37:03	0:00:59	59			I'm not doing this! I'm not doing this!	
0:38:05	0:37:03	0:01:02	62			I'd better do something.	
0:38:26	0:37:03	0:01:23	83		Ok, I'll take control.	You'll take control (laughs)	
0:38:27	0:37:03	0:01:24	84				VSS Disconnect
0:38:44	0:37:03	0:01:41	101		Now we're really done.		
0:38:45	0:37:03	0:01:42	102			Thanks, Jerk!	

Time	Start Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:38:46	0:37:03	0:01:43	103	(Laughs)	Ahh, that's a new one.		

19.4.5 Subject 5

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Nagoya			
0:00:48	0:00:48	0:00:00	0				Data Record 5
0:00:59	0:00:48	0:00:11	11	ATC Call to Turn			
0:01:34	0:00:48	0:00:46	46	ATC Call to Turn			
0:01:52	0:00:48	0:01:04	64	ATC Advisory			
0:03:44	0:00:48	0:02:56	176	ATC Switch to Tower			
0:03:58	0:00:48	0:03:10	190	ATC Clearance to Land			
0:04:48	0:00:48	0:04:00	240		Don't chase the glide slope here. We're going high! You're going high!		
0:04:52	0:00:48	0:04:04	244			Let's go max power. I don't know what's going on here.	
0:04:53	0:00:48	0:04:05	245		Max power set.		
0:04:56	0:00:48	0:04:08	248		Watch your airspeed.		
0:05:01	0:00:48	0:04:13	253		Watch your airspeed.		VSS Disconnect
0:05:02	0:00:48	0:04:14	254		Ok, I have control.		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:05:18	0:00:48	0:04:30	270			The only thing I can think I could have used is trip runaway. ... . I don't know....	
0:06:27				Script Roselawn			
0:06:53	0:06:53	0:00:00	0				Data Record 6
0:07:24	0:06:53	0:00:31	31	ATC Call for Spacing			
0:08:17	0:06:53	0:01:24	84	ATC Call to Turn			
0:08:27	0:06:53	0:01:34	94			Ah!!	
0:08:34	0:06:53	0:01:41	101			Ok, we're not going to be able to make that turn to 120.	
0:08:48	0:06:53	0:01:55	115			It freezed up. Locked aileron.	
0:08:51	0:06:53	0:01:58	118		Pull right.	I'm back all right.	
0:08:55	0:06:53	0:02:02	122			Not again!	
0:09:01	0:06:53	0:02:08	128			Argh! (Heavy breathing)	
0:09:07	0:06:53	0:02:14	134		Ok, I'm going to go ahead and take it.		
0:09:09	0:06:53	0:02:16	136		I have control.		VSS Disconnect
0:10:48				Script Shemya			
0:11:08	0:11:08	0:00:00	0				Data Record 7
0:11:47	0:11:08	0:00:39	39				VSS Disconnect
0:11:48	0:11:08	0:00:40	40		Ok, I have control.		
0:14:49				Script Birmingham			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:17:20	0:17:20	0:00:00	0				Data Record 10
0:17:37	0:17:20	0:00:17	17	ATC Call to Turn			
0:18:19	0:17:20	0:00:59	59	ATC Call to Turn			
0:19:58	0:17:20	0:02:38	158			Ok, set max power!	
0:19:59	0:17:20	0:02:39	159		Max power set.		
0:20:03	0:17:20	0:02:43	163			Ah!	
0:20:06	0:17:20	0:02:46	166			Pull it back to 80% power.	
0:20:07	0:17:20	0:02:47	167				VSS Disconnect
0:20:08	0:17:20	0:02:48	168			Whoa!	
0:20:10	0:17:20	0:02:50	170		I have control.		
0:21:55				Script Toledo			
0:22:32	0:22:32	0:00:00	0				Data Record 11
0:22:47	0:22:32	0:00:15	15	ATC Contact Departure			
0:23:00	0:22:32	0:00:28	28	ATC Climb			
0:23:19	0:22:32	0:00:47	47	ATC Call to Turn			
0:23:29	0:22:32	0:00:57	57		You got it? You got it?!		
0:23:30	0:22:32	0:00:58	58			I don't have it!	
0:23:33	0:22:32	0:01:01	61			I have it now.	
0:24:11	0:22:32	0:01:39	99		Ok, I'll take it.		
0:24:12	0:22:32	0:01:40	100				VSS Disconnect
0:24:13	0:22:32	0:01:41	101		I have control.	Your flight controls.	
0:25:38				Script Detroit			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:26:15	0:26:15	0:00:00	0				Data Record 12
0:26:40	0:26:15	0:00:25	25	ATC Call to Slow Down			
0:27:26	0:26:15	0:01:11	71			Ah!	
0:27:34	0:26:15	0:01:19	79			Oh!	
0:27:37	0:26:15	0:01:22	82		Watch your altitude.		
0:27:38	0:26:15	0:01:23	83			I'm trying!	
0:27:39	0:26:15	0:01:24	84		Ok, I have control.		VSS Disconnect
0:29:00				Script Charlotte			
0:29:54	0:29:54	0:00:00	0				Data Record 13
0:30:05	0:29:54	0:00:11	11	ATC Call to Turn			
0:30:41	0:29:54	0:00:47	47	ATC Call to Turn			
0:32:42	0:29:54	0:02:48	168	ATC Switch to Tower			
0:33:05	0:29:54	0:03:11	191	ATC Clearance to Land			
0:34:16	0:29:54	0:04:22	262		!	Whoa! Windshear! We've got a windshear	
0:34:18	0:29:54	0:04:24	264			Lets go max power!	
0:34:19	0:29:54	0:04:25	265		Max power set.		
0:34:22	0:29:54	0:04:28	268		Max power set.		
0:34:24	0:29:54	0:04:30	270			Just climbing up straight ahead here.	
0:34:26	0:29:54	0:04:32	272		Ok.		
0:34:30	0:29:54	0:04:36	276		350 AGL		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:34:51	0:29:54	0:04:57	297		Ok, I'll go ahead and take it.		
0:34:52	0:29:54	0:04:58	298			Ok, your flight controls.	VSS Disconnect
0:34:53	0:29:54	0:04:59	299		My controls.		
0:35:59				Script Pittsburgh			
0:36:44	0:36:44	0:00:00	0				Data Record 14
0:36:54	0:36:44	0:00:10	10	ATC Call to Turn			
0:37:28	0:36:44	0:00:44	44		A little bit slow.		
0:37:32	0:36:44	0:00:48	48			Ah!	
0:37:35	0:36:44	0:00:51	51		Ok, I have control.	Yea.	VSS Disconnect
0:37:55				Surprise Birmingham			Data Record 15
0:39:29	0:39:29	0:00:00	0			Ah! (Laughs)	
0:39:39	0:39:29	0:00:10	10			Ah! We're pitching up!	
0:39:41	0:39:29	0:00:12	12			What's going on?	
0:39:42	0:39:29	0:00:13	13		Ok, I have control.		VSS Disconnect

19.4.6 Subject 6

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Charlotte			
0:00:33	0:00:33	0:00:00	0				Data Record 5
0:00:43	0:00:33	0:00:10	10	ATC Call to Turn			
0:01:17	0:00:33	0:00:44	44	ATC Call to Turn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:03:02	0:00:33	0:02:29	149	ATC Switch to Tower			
0:03:18	0:00:33	0:02:45	165	ATC Clearance to Land			
0:04:24	0:00:33	0:03:51	231			Ah set max thrust!	
0:04:25	0:00:33	0:03:52	232		Max thrust set.		
0:04:37	0:00:33	0:04:04	244		Ok, that's the end of that scenario		VSS Disconnect
0:04:38	0:00:33	0:04:05	245		All right, I have the airplane.		
0:06:02				Script Birmingham			
0:06:32	0:06:32	0:00:00	0				Data Record 6
0:06:51	0:06:32	0:00:19	19	ATC Call to Turn			
0:07:31	0:06:32	0:00:59	59	ATC Call to Turn			
0:09:05	0:06:32	0:02:33	153			Set max thrust!	
0:09:06	0:06:32	0:02:34	154		Max thrust set		
0:09:14	0:06:32	0:02:42	162			Ok. Emergency trim.	
0:09:16	0:06:32	0:02:44	164		I have the airplane.		VSS Disconnect
0:10:36				Script Nagoya			
0:11:04	0:11:04	0:00:00	0				Data Record 7
0:11:15	0:11:04	0:00:11	11	ATC Call to Turn			
0:11:46	0:11:04	0:00:42	42	ATC Call to Turn			
0:12:02	0:11:04	0:00:58	58	ATC Advisory			
0:13:31	0:11:04	0:02:27	147	ATC Switch to Tower			
0:13:51	0:11:04	0:02:47	167	ATC Clearance to Land			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:15:08	0:11:04	0:04:04	244			Now we've come across something. Max thrust!	
0:15:09	0:11:04	0:04:05	245		Max thrust set.		
0:15:19	0:11:04	0:04:15	255			And positive rate, gear up.	
0:15:21	0:11:04	0:04:17	257		Gear coming up.	Flaps eight.	
0:15:22	0:11:04	0:04:18	258		Flaps set.		
0:15:32	0:11:04	0:04:28	268			Nose up trim.	
0:15:33	0:11:04	0:04:29	269		Say again?		
0:15:35	0:11:04	0:04:31	271			Nose up trim.	
0:15:37	0:11:04	0:04:33	273			Now we're going disconnected	
0:15:39	0:11:04	0:04:35	275		Ok, I have the airplane.		VSS Disconnect
0:17:18				Script Detroit			
0:17:42	0:17:42	0:00:00	0				Data Record 8
0:18:20	0:17:42	0:00:38	38	ATC Call to Slow Down			
0:19:18	0:17:42	0:01:36	96			Ok, set max trust!	
0:19:19	0:17:42	0:01:37	97		Thrust is set.		
0:19:36	0:17:42	0:01:54	114				VSS Disconnect
0:19:37	0:17:42	0:01:55	115		Ok, I have the airplane.		
0:21:03				Script Shemya			
0:21:19	0:21:19	0:00:00	0				Data Record 9
0:21:52	0:21:19	0:00:33	33				VSS Disconnect
0:21:53	0:21:19	0:00:34	34		Ok, I have the airplane.		
0:23:56				Script Toledo			
0:24:32	0:24:32	0:00:00	0				Data

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Record 11
0:24:41	0:24:32	0:00:09	9	ATC Contact Departure			
0:24:55	0:24:32	0:00:23	23	ATC Climb			
0:25:21	0:24:32	0:00:49	49	ATC Call to Turn			
0:25:28	0:24:32	0:00:56	56			Over bank! Correcting. Correct right. Correct right.	
0:25:29	0:24:32	0:00:57	57		You have the airplane?		
0:25:30	0:24:32	0:00:58	58			I have control!	
0:25:55	0:24:32	0:01:23	83		Ok I have the airplane.		VSS Disconnect
0:27:08				Script Pittsburgh			
0:27:31	0:27:31	0:00:00	0				Data Record 12
0:27:46	0:27:31	0:00:15	15	ATC Call to Turn			
0:28:29	0:27:31	0:00:58	58			Ok, set max thrust!	
0:28:30	0:27:31	0:00:59	59		Thrust is set.		
0:28:33	0:27:31	0:01:02	62		I have the airplane.		VSS Disconnect
0:30:15				Script Roselawn			
0:30:35	0:30:35	0:00:00	0				Data Record 13
0:31:08	0:30:35	0:00:33	33	ATC Call for Spacing			
0:31:54	0:30:35	0:01:19	79	ATC Call to Turn			
0:32:05	0:30:35	0:01:30	90			I'm getting some oscillation on the controls!	
0:32:11	0:30:35	0:01:36	96			Max Thrust!	
0:32:12	0:30:35	0:01:37	97				VSS Disconnect
0:32:13	0:30:35	0:01:38	98		Ok, I have the airplane.		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:32:32				Surprise Birmingham			Data Record 14
0:33:39	0:33:39	0:00:00	0			Huh?	
0:33:43	0:33:39	0:00:04	4			I'm loosing flight controls here. If you would like to take it back…	
0:33:46	0:33:39	0:00:07	7		Say again?		
0:33:47	0:33:39	0:00:08	8			I'm losing the controls.	
0:33:51	0:33:39	0:00:12	12		Ok, I have the airplane.		
0:33:52	0:33:39	0:00:13	13				VSS Disconnect

19.4.7 Subject 7

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Detroit			
0:00:36	0:00:36	0:00:00	0				Data Record 5
0:01:04	0:00:36	0:00:28	28	ATC Call to Slow Down			
0:01:40	0:00:36	0:01:04	64			Whoa!	
0:01:48	0:00:36	0:01:12	72			Let's pick up the airspeed here.	
0:01:50	0:00:36	0:01:14	74		Ok		
0:01:53	0:00:36	0:01:17	77		Let's make sure the anti ice system is working.		
0:02:03	0:00:36	0:01:27	87			Can you see if we have any buildup on the wings.	
0:02:09	0:00:36	0:01:33	93		All right, I'll take the airplane.		VSS Disconnect
0:02:12	0:00:36	0:01:36	96		Ok. were done with		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
					that scenario.		
0:03:47				Script Nagoya			
0:04:27	0:04:27	0:00:00	0				Data Record 6
0:04:42	0:04:27	0:00:15	15	ATC Call to Turn			
0:05:47	0:04:27	0:01:20	80	ATC Call to Turn			
0:06:06	0:04:27	0:01:39	99	ATC Advisory			
0:07:33	0:04:27	0:03:06	186	ATC Switch to Tower			
0:07:50	0:04:27	0:03:23	203	ATC Clearance to Land			
0:09:44	0:04:27	0:05:17	317			Ok, we have a runaway trim!	
0:09:48	0:04:27	0:05:21	321			Would you pull the trim circuit breaker please!	
0:09:50	0:04:27	0:05:23	323		Ok sir, it's pulled.		
0:09:54	0:04:27	0:05:27	327			Ok, this is a bad situation.	
0:10:00	0:04:27	0:05:33	333			Let's still push.	
0:10:03	0:04:27	0:05:36	336		Ok, I have the airplane.		VSS Disconnect
0:10:06	0:04:27	0:05:39	339			Well what I was going to attempt to do was roll it on its side a little bit to get the nose down but I guess I waited too long.	
0:11:10				Script Birmingham			
0:12:05	0:12:05	0:00:00	0				Data Record 7
0:12:18	0:12:05	0:00:13	13	ATC Call to Turn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:12:53	0:12:05	0:00:48	48	ATC Call to Turn			
0:14:32	0:12:05	0:02:27	147			Let's go max thrust.	
0:14:33	0:12:05	0:02:28	148		Ok set.		
0:14:34	0:12:05	0:02:29	149				VSS Disconnect
0:14:35	0:12:05	0:02:30	150		Ok, I have the airplane.		
0:16:06				Script Charlotte			
0:16:31	0:16:31	0:00:00	0				Data Record 8
0:16:41	0:16:31	0:00:10	10	ATC Call to Turn			
0:18:09	0:16:31	0:01:38	98	ATC Call to Turn			
0:20:25	0:16:31	0:03:54	234	ATC Switch to Tower			
0:20:41	0:16:31	0:04:10	250	ATC Clearance to Land			
0:22:07	0:16:31	0:05:36	336			Max Thrust!	
0:22:08	0:16:31	0:05:37	337		Ok, thrust is set.		
0:22:32	0:16:31	0:06:01	361		Very nice, ok I have the airplane.		
0:22:33	0:16:31	0:06:02	362				VSS Disconnect
0:23:11				Script Roselawn			
0:23:50	0:23:50	0:00:00	0				Data Record 9
0:24:22	0:23:50	0:00:32	32	ATC Call to			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Turn			
0:25:12	0:23:50	0:01:22	82			Max thrust!	
0:25:13	0:23:50	0:01:23	83		Ok, set.		
0:25:15	0:23:50	0:01:25	85			Ok, tell him we ah … had a little bit of a stall there, I want 220, if he won't give it too us I am going to do it anyway!	
0:25:22	0:23:50	0:01:32	92		Ok.		
0:25:32	0:23:50	0:01:42	102	ATC Call to Turn			
0:25:40	0:23:50	0:01:50	110			Ok, let's keep that throttle up a little here, I don't want to go to slow. I'd like 220 If you can do that. What was that heading.	
0:25:46	0:23:50	0:01:56	116		300		
0:26:56	0:23:50	0:03:06	186		All right, that's the end of that scenario.		
0:26:57	0:23:50	0:03:07	187				VSS Disconnect
0:26:59	0:23:50	0:03:09	189		I have the airplane.		
0:27:17				Script Pittsburgh			
0:28:07	0:28:07	0:00:00	0				Data Record 10
0:28:18	0:28:07	0:00:11	11	ATC Call to Turn			
0:29:07	0:28:07	0:01:00	60			Ok, this is bad!	
0:29:10	0:28:07	0:01:03	63			Throttle idle.	
0:29:11	0:28:07	0:01:04	64		Idle		
0:29:13	0:28:07	0:01:06	66		Ok, I have the airplane		
0:29:14	0:28:07	0:01:07	67				VSS Disconnect
0:30:20				Script			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Toledo			
0:30:56	0:30:56	0:00:00	0				Data Record 11
0:31:20	0:30:56	0:00:24	24	ATC Contact Departure			
0:31:34	0:30:56	0:00:38	38	ATC Climb			
0:31:57	0:30:56	0:01:01	61	ATC Call to Turn			
0:32:05	0:30:56	0:01:09	69			Watch your bank!	
0:32:06	0:30:56	0:01:10	70			Right. Right bank. Right bank!	
0:32:10	0:30:56	0:01:14	74		You have the airplane?	No!	
0:32:11	0:30:56	0:01:15	75				VSS Disconnect
0:32:12	0:30:56	0:01:16	76		I have the airplane. My airplane.		
0:33:32				Script Shemya			
0:33:54	0:33:54	0:00:00	0				Data Record 12
0:34:34	0:33:54	0:00:40	40				VSS Disconnect
0:34:35	0:33:54	0:00:41	41		Ok, I have the airplane.		
0:35:36	0:35:36	0:00:00	0	Surprise Nagoya			Data Record 14
0:37:15	0:35:36	0:01:39	99			That's. That's very interesting. (Muttered)	
0:37:28	0:35:36	0:01:52	112				VSS

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Disconnect
0:37:29	0:35:36	0:01:53	113		Ok, I have the airplane.		

19.4.8 Subject 8

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Charlotte			
0:00:55	0:00:55	0:00:00	0				Data Record 8
0:01:14	0:00:55	0:00:19	19	ATC Call to Turn			
0:01:51	0:00:55	0:00:56	56	ATC Call to Turn			
0:03:59	0:00:55	0:03:04	184	ATC Switch to Tower			
0:04:14	0:00:55	0:03:19	199	ATC Clearance to Land			
0:06:22	0:00:55	0:05:27	327			Max Power! Half Flaps!	
0:06:24	0:00:55	0:05:29	329		Power set.		
0:06:35	0:00:55	0:05:40	340		Ok, I have control		VSS Disconnect
0:07:30				Script Detroit			
0:08:11	0:08:11	0:00:00	0				Data Record 9
0:08:36	0:08:11	0:00:25	25	ATC Call to Slow down			
0:09:14	0:08:11	0:01:03	63			Max power!	
0:09:15	0:08:11	0:01:04	64		Ok, power set.		
0:09:20	0:08:11	0:01:09	69				VSS Disconnect
0:09:21	0:08:11	0:01:10	70		Ok, I have the airplane.		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:23:00				Script Pittsburgh			
0:24:57	0:24:57	0:00:00	0				Data Record 10
0:25:08	0:24:57	0:00:11	11	ATC Call to Turn			
0:25:49	0:24:57	0:00:52	52			Max power!	
0:25:50	0:24:57	0:00:53	53		Max power set.		
0:25:58	0:24:57	0:01:01	61		I have control.		VSS Disconnect
0:26:02	0:24:57	0:01:05	65		My airplane, end of the scenario.		
0:15:11				Script Birmingham			
0:15:40	0:15:40	0:00:00	0				Data Record 11
0:15:58	0:15:40	0:00:18	18	ATC Call to Turn			
0:16:30	0:15:40	0:00:50	50	ATC Call to Turn			
0:17:33	0:15:40	0:01:53	113			Max power!	
0:17:34	0:15:40	0:01:54	114		Ok, max power set.		
0:17:45	0:15:40	0:02:05	125			Emergency trim!	VSS Disconnect
0:17:46	0:15:40	0:02:06	126		I have the airplane.		
0:18:52				Script Roselawn			
0:19:32	0:19:32	0:00:00	0				Data Record 12
0:20:04	0:19:32	0:00:32	32	ATC Speed			
0:20:47	0:19:32	0:01:15	75			(Argh) Max power!	
0:20:48	0:19:32	0:01:16	76		Power set.		
0:20:51	0:19:32	0:01:19	79		I have the airplane.		VSS Disconnect
0:21:42				Script Shemya			
0:21:58	0:21:58	0:00:00	0				Data Record

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							13
0:22:39	0:21:58	0:00:41	41		Ok, I have the airplane.		VSS Disconnect
0:24:03				Script Nagoya			
0:24:55	0:24:55	0:00:00	0				Data Record 15
0:25:06	0:24:55	0:00:11	11	ATC Call to Turn			
0:25:43	0:24:55	0:00:48	48	ATC Call to Turn			
0:26:00	0:24:55	0:01:05	65	ATC Advisory			
0:27:45	0:24:55	0:02:50	170	ATC Switch to Tower			
0:28:01	0:24:55	0:03:06	186	ATC Clearance to Land			
0:29:33	0:24:55	0:04:38	278			Ok, Max power.	
0:29:34	0:24:55	0:04:39	279		ok, Power set.		
0:29:35	0:24:55	0:04:40	280			Emergency Trim.	
0:29:36	0:24:55	0:04:41	281		Ok, you got it.		
0:29:55	0:24:55	0:05:00	300		Very nice, I've got the airplane.		
0:29:56	0:24:55	0:05:01	301				VSS Disconnect
0:30:31				Script Toledo			
0:31:30	0:31:30	0:00:00	0				Data Record 16
0:31:40	0:31:30	0:00:10	10	ATC Contact Departure			
0:31:52	0:31:30	0:00:22	22	ATC Climb			
0:32:15	0:31:30	0:00:45	45			Ok, Captain, we are getting a little slow.	
0:32:17	0:31:30	0:00:47	47	ATC Call to Turn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:32:25	0:31:30	0:00:55	55			Watch it! My airplane.	
0:32:26	0:31:30	0:00:56	56		You have the airplane.		
0:32:33	0:31:30	0:01:03	63			Give me max power.	
0:32:34	0:31:30	0:01:04	64		Ok.		
0:32:41	0:31:30	0:01:11	71		Ok, That's the end of the scenario.		
0:32:42	0:31:30	0:01:12	72		My airplane.		
0:32:43	0:31:30	0:01:13	73				VSS Disconnect
0:32:57				Surprise Birmingham			Data Record 17
0:35:24	0:35:24	0:00:00	0			Emergency trim!	
0:35:25	0:35:24	0:00:01	1		I have the airplane.		VSS Disconnect

19.5 IN-FLIGHT GROUP

19.5.1 Subject 1

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Toledo			
0:01:46	0:01:46	0:00:00	0				Data Record 6
0:01:56	0:01:46	0:00:10	10	ATC Contact Departure			
0:02:10	0:01:46	0:00:24	24	ATC Climb			
0:02:34	0:01:46	0:00:48	48	ATC Call to Turn			
0:02:42	0:01:46	0:00:56	56			Oh!	
0:02:43	0:01:46	0:00:57	57			My controls!	
0:02:45	0:01:46	0:00:59	59		You got it?		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:02:46	0:01:46	0:01:00	60			Yup.	
0:02:49	0:01:46	0:01:03	63			Max power.	
0:02:50	0:01:46	0:01:04	64		Max Power		
0:02:57	0:01:46	0:01:11	71		Ok, I'll go ahead and take it here.	Ok.	
0:02:59	0:01:46	0:01:13	73		I have control.		VSS Disconnect
0:03:39				Script Roselawn			
0:04:50	0:04:50	0:00:00	0				Data Record 7
0:05:19	0:04:50	0:00:29	29	ATC Call for Spacing			
0:05:37	0:04:50	0:00:47	47			Oh!	
0:05:42	0:04:50	0:00:52	52			(Wheel column broke)	
0:05:43	0:04:50	0:00:53	53		Ok, I have control.		VSS Disconnect

19.5.2 Subject 2

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Birmingham			
0:00:34	0:00:34	0:00:00	0				Data Record 5
0:00:48	0:00:34	0:00:14	14	ATC Call to Turn			
0:01:25	0:00:34	0:00:51	51	ATC Call to Turn			
0:02:48	0:00:34	0:02:14	134			OOOOK!	
0:02:52	0:00:34	0:02:18	138			And Set Max power.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:02:53	0:00:34	0:02:19	139		Max power set.		
0:02:58	0:00:34	0:02:24	144		Watch your airspeed!		
0:02:59	0:00:34	0:02:25	145			Argh!	
0:03:01	0:00:34	0:02:27	147			It looks like I have a trim runaway.	
0:03:02	0:00:34	0:02:28	148				VSS Disconnect
0:03:03	0:00:34	0:02:29	149		Ok, I have control.		
0:03:57				Script Charlotte			
0:04:55	0:04:55	0:00:00	0				Data Record 6
0:05:03	0:04:55	0:00:08	8	ATC Call to Turn			
0:05:30	0:04:55	0:00:35	35	ATC Call to Turn			
0:07:27	0:04:55	0:02:32	152	ATC Switch to Tower			
0:07:38	0:04:55	0:02:43	163	ATC Clearance to Land			
0:08:42	0:04:55	0:03:47	227			Oh, We have a windshear! We've got a windshear!	
0:08:44	0:04:55	0:03:49	229			Set max power!	
0:08:45	0:04:55	0:03:50	230		Max power.		
0:08:47	0:04:55	0:03:52	232		Max power set.		
0:08:56	0:04:55	0:04:01	241		Max power set.		
0:09:00	0:04:55	0:04:05	245		Looking good, airspeed is low but...		
0:09:04	0:04:55	0:04:09	249		Ok, I have control.	You have control.	
0:09:05	0:04:55	0:04:10	250				VSS Disconnect
0:11:21				Script			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Roselawn			
0:11:44	0:11:44	0:00:00	0				Data Record 7
0:12:15	0:11:44	0:00:31	31	ATC Call for Spacing			
0:12:30	0:11:44	0:00:46	46			Flaps up.	
0:12:31	0:11:44	0:00:47	47		Flaps selected up.		
0:12:32	0:11:44	0:00:48	48			Flaps back down!	
0:12:34	0:11:44	0:00:50	50		Flaps back down.		
0:12:37	0:11:44	0:00:53	53		You've got the flaps back down.	Ok.	
0:12:39	0:11:44	0:00:55	55			Set max power!	
0:12:40	0:11:44	0:00:56	56		Max power set!		
0:12:46	0:11:44	0:01:02	62		Actually we better not set too much max power on the real Learjet.		
0:12:49	0:11:44	0:01:05	65		Ok. I have control.		VSS Disconnect
0:12:50	0:11:44	0:01:06	66			You have control.	
0:13:41				Script Pittsburgh			
0:14:08	0:14:08	0:00:00	0				Data Record 8
0:14:27	0:14:08	0:00:19	19	ATC Call to Turn			
0:15:13	0:14:08	0:01:05	65			Ok, I've got a rudder trim runaway!	
0:15:15	0:14:08	0:01:07	67			Bring back the right engine, right throttle forward!	
0:15:18	0:14:08	0:01:10	70		Ok, got it.		
0:15:21	0:14:08	0:01:13	73			Revert to emergency trim if we got it!	
0:15:23	0:14:08	0:01:15	75		Ok, it's selected.		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:15:24	0:14:08	0:01:16	76			Full power on the left engine or bring the power up there.	
0:15:27	0:14:08	0:01:19	79		Ok.		
0:15:30	0:14:08	0:01:22	82		We've got as much as we can get.		
0:15:31	0:14:08	0:01:23	83			Ok.	
0:15:35	0:14:08	0:01:27	87		Ok, I'm going to take control.		
0:15:37	0:14:08	0:01:29	89			Ok.	
0:15:38	0:14:08	0:01:30	90				VSS Disconnect
0:16:53				Script Toledo			
0:18:44	0:18:44	0:00:00	0				Data Record 9
0:18:54	0:18:44	0:00:10	10	ATC Contact Departure			
0:19:08	0:18:44	0:00:24	24	ATC Climb			
0:19:31	0:18:44	0:00:47	47	ATC Call to Turn			
0:19:41	0:18:44	0:00:57	57			Uh, watch that bank angle!	
0:19:42	0:18:44	0:00:58	58		You got it?		
0:19:43	0:18:44	0:00:59	59		You got it? Ok.		
0:19:59	0:18:44	0:01:15	75			Ok.	
0:20:00	0:18:44	0:01:16	76		Ok, I'll take control.		
0:20:01	0:18:44	0:01:17	77			You have control.	
0:20:02	0:18:44	0:01:18	78		I have it.		
0:20:03	0:18:44	0:01:19	79				VSS Disconnect
0:20:57				Script Shemya			
0:21:39	0:21:39	0:00:00	0				Data Record 10
0:22:25	0:21:39	0:00:46	46			Argh.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:22:26	0:21:39	0:00:47	47				VSS Disconnect
0:22:28	0:21:39	0:00:49	49		I have control.		
0:25:21				Script Detroit			
0:26:21	0:26:21	0:00:00	0				Data Record 12
0:26:49	0:26:21	0:00:28	28	ATC Call to Slow Down			
0:27:13	0:26:21	0:00:52	52			Ok, (ARGH) set max power!	
0:27:15	0:26:21	0:00:54	54		Max power.		
0:27:19	0:26:21	0:00:58	58		Max power set.		
0:27:21	0:26:21	0:01:00	60			Man!	
0:27:44	0:26:21	0:01:23	83		Ok, I have control.		
0:27:45	0:26:21	0:01:24	84				VSS Disconnect
0:28:35				Script Nagoya			
0:29:20	0:29:20	0:00:00	0				Data Record 13
0:29:30	0:29:20	0:00:10	10	ATC Call to Turn			
0:30:05	0:29:20	0:00:45	45	ATC Call to Turn			
0:30:22	0:29:20	0:01:02	62	ATC Advisory			
0:31:35	0:29:20	0:02:15	135	ATC Switch to Tower			
0:31:52	0:29:20	0:02:32	152	ATC Clearance to Land			
0:33:32	0:29:20	0:04:12	252			Ok…Set max power.	
0:33:34	0:29:20	0:04:14	254		Max power.		
0:33:35	0:29:20	0:04:15	255		Max power set.		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:33:36	0:29:20	0:04:16	256			It looks like we got an elevator trim runaway.	
0:33:37	0:29:20	0:04:17	257		Ok.		
0:33:38	0:29:20	0:04:18	258			Emergency trim.	
0:33:39	0:29:20	0:04:19	259		Emergency trim selected.		
0:34:02	0:29:20	0:04:42	282		Ok, all right I'll take control.		
0:34:06	0:29:20	0:04:46	286				VSS Disconnect
0:34:07	0:29:20	0:04:47	287		I have control.		
0:34:26	0:34:26	0:00:00	0	Surprise Nagoya			Data Record 14
0:35:25	0:34:26	0:00:59	59			Ok. I've got a trim runaway here.	
0:35:33	0:34:26	0:01:07	67			You want to emergency trim!	
0:35:34	0:34:26	0:01:08	68		Ok, emergency trim.		
0:35:42	0:34:26	0:01:16	76		Ok, you got that one.		VSS Disconnect

19.5.3 Subject 3

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Pittsburgh			
0:00:34	0:00:34	0:00:00	0				Data Record 5
0:00:46	0:00:34	0:00:12	12	ATC Call to Turn			
0:01:42	0:00:34	0:01:08	68			I've got no rudder control, correcting with the aileron.	
0:01:47	0:00:34	0:01:13	73		Ok.		
0:01:49	0:00:34	0:01:15	75			Differential Power.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:01:50	0:00:34	0:01:16	76		Ok.		
0:01:53	0:00:34	0:01:19	79			I hope that's it.	
0:02:00	0:00:34	0:01:26	86			Lets declare an emergency.	
0:02:01	0:00:34	0:01:27	87		Ok. I'll go ahead and take it now.		
0:02:03	0:00:34	0:01:29	89				VSS Disconnect
0:02:57				Script Shemya			
0:04:22	0:04:22	0:00:00	0				Data Record 6
0:05:15	0:04:22	0:00:53	53			Oh!	
0:05:16	0:04:22	0:00:54	54				VSS Disconnect
0:05:17	0:04:22	0:00:55	55		Ok, I have control.		
0:07:49				Script Charlotte			
0:08:35	0:08:35	0:00:00	0				Data Record 8
0:08:46	0:08:35	0:00:11	11	ATC Call to Turn			
0:09:22	0:08:35	0:00:47	47	ATC Call to Turn			
0:11:21	0:08:35	0:02:46	166	ATC Switch to Tower			
0:11:35	0:08:35	0:03:00	180	ATC Clearance to Land			
0:13:44	0:08:35	0:05:09	309			Ok, we have a windshear, a windshear!	
0:13:46	0:08:35	0:05:11	311				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:13:47	0:08:35	0:05:12	312		Ok, I have control.		
0:14:58				Script Nagoya			
0:15:39	0:15:39	0:00:00	0				Data Record 9
0:15:52	0:15:39	0:00:13	13	ATC Call to Turn			
0:16:32	0:15:39	0:00:53	53	ATC Call to Turn			
0:16:52	0:15:39	0:01:13	73	ATC Advisory			
0:18:19	0:15:39	0:02:40	160	ATC Switch to Tower			
0:18:33	0:15:39	0:02:54	174	ATC Clearance to Land			
0:20:06	0:15:39	0:04:27	267		Got ya going a little high.		
0:20:07	0:15:39	0:04:28	268			Ok.	
0:20:11	0:15:39	0:04:32	272		Got ya going high.		
0:20:13	0:15:39	0:04:34	274			Disconnecting. Emergency trim.	
0:20:16	0:15:39	0:04:37	277				VSS Disconnect
0:20:17	0:15:39	0:04:38	278		Ok, I have control.		
0:21:24				Script Detroit			
0:22:09	0:22:09	0:00:00	0				Data Record 10
0:22:38	0:22:09	0:00:29	29	ATC Call to Slow Down			
0:22:48	0:22:09	0:00:39	39			Something's wrong, I've got a rudder input here.	
0:22:56	0:22:09	0:00:47	47		I'll let up and let's see what happens.		
0:22:59	0:22:09	0:00:50	50		I think it was just a little chop, probably a little		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
					turbulence.		
0:23:50	0:22:09	0:01:41	101			Argh!	
0:24:01	0:22:09	0:01:52	112			Tell them were at 350 .	
0:24:03	0:22:09	0:01:54	114		Approach we are at 3500 with a problem here. Veridian 102 we will get back to you.		
0:24:16	0:22:09	0:02:07	127		Ok, I think we have that one under control. I'll take it.		
0:24:18	0:22:09	0:02:09	129				VSS Disconnect
0:25:04				Script Birmingham			
0:25:45	0:25:45	0:00:00	0				Data Record 11
0:26:03	0:25:45	0:00:18	18	ATC Call to Turn			
0:26:44	0:25:45	0:00:59	59	ATC Call to Turn			
0:27:48	0:25:45	0:02:03	123			Careful, Rudder!	
0:27:50	0:25:45	0:02:05	125		Oh you have rudder.		
0:27:55	0:25:45	0:02:10	130			Trim! Trim!	
0:27:28	0:25:45	0:01:43	103		Ok, I'm Trimming.		
0:28:00	0:25:45	0:02:15	135			Emergency Trim please!	
0:28:01	0:25:45	0:02:16	136		Emergency Trim.		
0:28:02	0:25:45	0:02:17	137				VSS Disconnect
0:28:03	0:25:45	0:02:18	138		Ok, I have control.		
0:28:55				Script Roselawn			
0:29:58	0:29:58	0:00:00	0				Data Record 12
0:30:32	0:29:58	0:00:34	34	ATC Call for			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Spacing			
0:30:56	0:29:58	0:00:58	58			Oh!	
0:31:01	0:29:58	0:01:03	63			Ok, tell them that we have a problem!	
0:31:03	0:29:58	0:01:05	65		Approach 102 we have a control problem.		
0:31:16	0:29:58	0:01:18	78		Ok we're complete.		
0:31:17	0:29:58	0:01:19	79				VSS Disconnect
0:32:30				Script Toledo			
0:33:26	0:33:26	0:00:00	0				Data Record 13
0:33:40	0:33:26	0:00:14	14	ATC Contact Departure			
0:33:58	0:33:26	0:00:32	32	ATC Climb			
0:34:12	0:33:26	0:00:46	46	ATC Call to Turn			
0:34:22	0:33:26	0:00:56	56			Wuh?	
0:34:23	0:33:26	0:00:57	57			Do you have a problem?	
0:34:24	0:33:26	0:00:58	58		You got it?		
0:34:31	0:33:26	0:01:05	65			I've got the controls!	
0:34:32	0:33:26	0:01:06	66		I've got control		
0:34:33	0:33:26	0:01:07	67				VSS Disconnect
0:35:02	0:35:02	0:00:00	0	Surprise Pittsburgh			Data Record 14
0:36:31	0:35:02	0:01:29	89			Argh! I have no controls!	
0:36:32	0:35:02	0:01:30	90				VSS Disconnect
0:36:33	0:35:02	0:01:31	91		Ok, I have control.		

19.5.4 Subject 4

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Roselawn			
0:00:37	0:00:37	0:00:00	0				Data Record 5
0:01:07	0:00:37	0:00:30	30	ATC Call for Spacing			
0:01:30	0:00:37	0:00:53	53			Ok we have....	
0:01:34	0:00:37	0:00:57	57			Ok, I have a hard over to the right!	
0:01:36	0:00:37	0:00:59	59				VSS Disconnect
0:01:37	0:00:37	0:01:00	60		Ok, I have the airplane.		Your airplane.
0:02:42				Script Nagoya			
0:03:16	0:03:16	0:00:00	0				Data Record 6
0:03:37	0:03:16	0:00:21	21	ATC Call to Turn			
0:04:44	0:03:16	0:01:28	88	ATC Call to Turn			
0:05:26	0:03:16	0:02:10	130	ATC Advisory			
0:06:10	0:03:16	0:02:54	174	ATC Switch to Tower			
0:06:25	0:03:16	0:03:09	189	ATC Clearance to Land			
0:08:19	0:03:16	0:05:03	303			Ok, Ah...Let's go ahead and go miss! Max Power!	
0:08:23	0:03:16	0:05:07	307		Max Power.		
0:08:24	0:03:16	0:05:08	308			And I have a.... Argh...Argh! Unscheduled pitch up!	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:08:28	0:03:16	0:05:12	312			Ok, calm. Airspeed. We are climbing.	
0:08:30	0:03:16	0:05:14	314			All right and ah no configuration changes. Let's just go ahead and fly this through.	
0:08:35	0:03:16	0:05:19	319		Ok.		
0:08:38	0:03:16	0:05:22	322		I have the airplane.		VSS Disconnect
0:09:28				Script Pittsburgh			
0:10:36	0:10:36	0:00:00	0				Data Record 7
0:10:51	0:10:36	0:00:15	15	ATC Call to Turn			
0:11:13	0:10:36	0:00:37	37			Ok, Did you feel that bump?	
0:11:14	0:10:36	0:00:38	38		Yes I did.		
0:11:22	0:10:36	0:00:46	46		It seems a little turbulent around here.		
0:11:26	0:10:36	0:00:50	50			Have you hear any windshear advisories?	
0:11:27	0:10:36	0:00:51	51		Not that I heard of.		
0:11:28	0:10:36	0:00:52	52			Ok, Good.	
0:11:40	0:10:36	0:01:04	64			Ok, I have a hard over!	
0:11:42	0:10:36	0:01:06	66			And ah ... help me out on the controls!	
0:11:43	0:10:36	0:01:07	67		I've got the controls with ya.		
0:11:44	0:10:36	0:01:08	68			Ok.	
0:11:45	0:10:36	0:01:09	69				VSS Disconnect
0:11:46	0:10:36	0:01:10	70		Ok, I have the airplane.		
0:12:49				Script Charlotte			
0:13:27	0:13:27	0:00:00	0			And ah. Possibility of windshear in the	Data

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
						area. Let's just discuss our windshear escape maneuver as we prepare for the approach here. Any exceeding windshear parameters we go ahead and identify them and its max power uh fifteen degrees pitch up with perspective stick shaker. And ah we will power out of it, no configuration changes when we fly through the maneuver will ...er when we fly through the encounter we'll execute or er we'll neg. Or we'll notify ATC.	Record 8
0:13:59	0:13:27	0:00:32	32		Ok, I concur.		
0:14:02	0:13:27	0:00:35	35	ATC Call to Turn			
0:14:43	0:13:27	0:01:16	76	ATC Call to Turn			
0:16:19	0:13:27	0:02:52	172	ATC Switch to Tower			
0:16:36	0:13:27	0:03:09	189	ATC Clearance to Land			
0:19:02	0:13:27	0:05:35	335			Ok, uh...I have a stick shaker. Max power.	
0:19:05	0:13:27	0:05:38	338		Max power set.		
0:19:07	0:13:27	0:05:40	340			Ok, positive rate.	
0:19:09	0:13:27	0:05:42	342		Positive rate.		
0:19:10	0:13:27	0:05:43	343			Thank you. Airspeed is increasing.	
0:19:12	0:13:27	0:05:45	345			I still have the shaker.	
0:19:16	0:13:27	0:05:49	349			And I show us climbing, airspeed increasing. Do you concur?	
0:19:18	0:13:27	0:05:51	351		Yes.	Ok.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:19:24	0:13:27	0:05:57	357		Very good. I have the airplane.		VSS Disconnect
0:20:34				Script Toledo			
0:21:00			0			Ok, well first of all I would never be in that scenario because I don't shoot a third approach, but we'll play...	
0:21:25	0:21:25	0:00:00	0				Data Record 9
0:21:35	0:21:25	0:00:10	10	ATC Contact Departure			
0:21:50	0:21:25	0:00:25	25	ATC Climb			
0:22:11	0:21:25	0:00:46	46	ATC Call to Turn			
0:22:21	0:21:25	0:00:56	56			Ok, ah. Hard over. Can you help me out with the controls sir?	
0:22:24	0:21:25	0:00:59	59		I have the airplane.		VSS Disconnect
0:23:26				Script Detroit			
0:24:04	0:24:04	0:00:00	0				Data Record 10
0:24:34	0:24:04	0:00:30	30	ATC Call to Slow Down			
0:25:14	0:24:04	0:01:10	70			Ok, I'm having a control difficulty, right rudder. And pitch attitude is unstable. All right, I'm going to go ahead and go max power.	
0:25:23	0:24:04	0:01:19	79		Ok, power set.		
0:25:24	0:24:04	0:01:20	80			Get the flaps back to where they were if you would please.	
0:25:25	0:24:04	0:01:21	81		They are.		
0:25:26	0:24:04	0:01:22	82			Thank you.	
0:25:29	0:24:04	0:01:25	85		I have the airplane.	Ah. Shit.	VSS

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Disconnect
0:26:29				Script Birmingham			
0:27:08	0:27:08	0:00:00	0				Data Record 11
0:27:25	0:27:08	0:00:17	17	ATC Call to Turn			
0:27:52	0:27:08	0:00:44	44	ATC Call to Turn			
0:28:11	0:27:08	0:01:03	63			And our windshear brief as we did before. Call any windshear parameters.	
0:28:16	0:27:08	0:01:08	68		Ok, I'll do that.		
0:28:52	0:27:08	0:01:44	104			Hard over to the left!	
0:28:56	0:27:08	0:01:48	108			Ok, ah, did you feel that?	
0:28:57	0:27:08	0:01:49	109		Yes sir.		
0:28:58	0:27:08	0:01:50	110			Ok, I've got a strong pitch up. I'm trimming. Go trim. Let's go ahead use emergency trim.	
0:29:03	0:27:08	0:01:55	115		Ok, emergency trim. You got it.		
0:29:09	0:27:08	0:02:01	121			Alright.	
0:29:13	0:27:08	0:02:05	125			Correcting on the altitude.	
0:29:16	0:27:08	0:02:08	128			and..	
0:29:17	0:27:08	0:02:09	129		I have the airplane.		VSS Disconnect
0:30:17				Script Shemya			
0:30:38	0:30:38	0:00:00	0				Data Record 12
0:31:14	0:30:38	0:00:36	36			Ok, autopilot is off.	
0:31:16	0:30:38	0:00:38	38				VSS

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Disconnect
0:31:17	0:30:38	0:00:39	39		Ok, I have the airplane.		
0:32:19	0:32:19	0:00:00	0	Surprise Nagoya			Data Record 14
0:33:40	0:32:19	0:01:21	81			Ok, I have a nose up condition. Full deflection.	
0:33:45	0:32:19	0:01:26	86			I have no trim response.	
0:33:48	0:32:19	0:01:29	89			Ok, let's go ahead and see...I'm going to add stick shaker, I'm going to add power. Ok we do have an emergency situation here, sir.	
0:33:58	0:32:19	0:01:39	99		Yes, sir.		
0:34:01	0:32:19	0:01:42	102		Ok, I have the airplane.		
0:34:02	0:32:19	0:01:43	103				VSS Disconnect

19.5.5 Subject 5

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Detroit			
0:00:37	0:00:37	0:00:00	0				Data Record 5
0:01:09	0:00:37	0:00:32	32	ATC Call to Slow Down			
0:02:00	0:00:37	0:01:23	83	ATC Call to Turn			
0:02:16	0:00:37	0:01:39	99			Ok, disconnecting.	
0:02:18	0:00:37	0:01:41	101		I have the airplane.		VSS Disconnect
0:03:22				Script			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
				Pittsburgh			
0:04:16	0:04:16	0:00:00	0				Data Record 6
0:04:35	0:04:16	0:00:19	19	ATC Call to Turn			
0:05:25	0:04:16	0:01:09	69			Ok, disconnecting.	
0:05:26	0:04:16	0:01:10	70		Ok.		
0:05:30	0:04:16	0:01:14	74			Correcting.	
0:05:39	0:04:16	0:01:23	83			And if you could please help with the ailerons.	
0:05:40	0:04:16	0:01:24	84		Ok, I'm helping.		
0:05:43	0:04:16	0:01:27	87			I have no rudder effectiveness.	
0:05:45	0:04:16	0:01:29	89			If you could please add power on the left engine.	
0:05:47	0:04:16	0:01:31	91		Very good.		
0:05:48	0:04:16	0:01:32	92				VSS Disconnect
0:05:49	0:04:16	0:01:33	93		Ok, I have the airplane.		
0:06:49				Script Birmingham			
0:07:20	0:07:20	0:00:00	0				Data Record 7
0:07:38	0:07:20	0:00:18	18	ATC Call to Turn			
0:08:18	0:07:20	0:00:58	58	ATC Call to Turn			
0:09:32	0:07:20	0:02:12	132			Ok, autopilot's disconnected.	
0:09:37	0:07:20	0:02:17	137			You want to call missed approach; we have some type of problem.	
0:09:42	0:07:20	0:02:22	142			Trim Runaway! Emergency trim!	
0:09:43	0:07:20	0:02:23	143		You've got emergency trim.		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:09:47	0:07:20	0:02:27	147		Ok, I have the airplane.		VSS Disconnect
0:11:05				Script Roselawn			
0:11:27	0:11:27	0:00:00	0				Data Record 8
0:11:49	0:11:27	0:00:22	22	ATC Spacing			
0:12:22	0:11:27	0:00:55	55			Ok, if you'd help with the ailerons!	
0:12:24	0:11:27	0:00:57	57		Ok.		
0:12:27	0:11:27	0:01:00	60			Ok, I have rudder control.	
0:12:31	0:11:27	0:01:04	64			Evidently we've got out of the aileron upset, go back to the flap configuration.	
0:12:36	0:11:27	0:01:09	69		Ok.		
0:12:37	0:11:27	0:01:10	70			And slow.	
0:12:39	0:11:27	0:01:12	72		We're above the flap speed.	Right.	
0:12:40	0:11:27	0:01:13	73	ATC Call to Turn			
0:12:47	0:11:27	0:01:20	80			Ok, declare an emergency, we have to let him know what's going on.	
0:13:00	0:11:27	0:01:33	93			Ok, flaps back out that did not work.	
0:13:01	0:11:27	0:01:34	94		Ok, flaps coming out.		
0:13:05	0:11:27	0:01:38	98			And I still need you aileron input to help with this control.	
0:13:08	0:11:27	0:01:41	101		Ok, I'm trying.		
0:13:15	0:11:27	0:01:48	108			All right.	
0:13:16	0:11:27	0:01:49	109				VSS Disconnect
0:13:17	0:11:27	0:01:50	110		End of the scenario. I have the airplane.		
0:14:08				Script Shemya			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:14:23	0:14:23	0:00:00	0				Data Record 9
0:15:03	0:14:23	0:00:40	40		I have control.	Ok, trim runaway.	VSS Disconnect
0:16:43				Script Nagoya			
0:17:10	0:17:10	0:00:00	0				Data Record 11
0:17:23	0:17:10	0:00:13	13	ATC Call to Turn			
0:17:51	0:17:10	0:00:41	41	ATC Call to Turn			
0:18:36	0:17:10	0:01:26	86	ATC Advisory			
0:19:54	0:17:10	0:02:44	164	ATC Switch to Tower			
0:20:33	0:17:10	0:03:23	203	ATC Clearance to Land			
0:23:12	0:17:10	0:06:02	362		Ok, I have the airplane.		VSS Disconnect
0:24:16				Script Toledo			
0:25:04	0:25:04	0:00:00	0				Data Record 12
0:25:13	0:25:04	0:00:09	9	ATC Contact Departure			
0:25:27	0:25:04	0:00:23	23	ATC Climb			
0:25:50	0:25:04	0:00:46	46	ATC Call to Turn			
0:25:58	0:25:04	0:00:54	54			Ok, too steep of a bank, Captain!	
0:26:01	0:25:04	0:00:57	57			Ok, helping.	
0:26:02	0:25:04	0:00:58	58		You have the airplane?		
0:26:03	0:25:04	0:00:59	59			I have the controls!	
0:26:08	0:25:04	0:01:04	64			Correcting for terrain.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:26:15	0:25:04	0:01:11	71		Very good.	and....	VSS Disconnect
0:26:16	0:25:04	0:01:12	72		I have the airplane.		
0:27:11				Script Charlotte			
0:27:37	0:27:37	0:00:00	0				Data Record 13
0:27:58	0:27:37	0:00:21	21	ATC Call to Turn			
0:28:24	0:27:37	0:00:47	47	ATC Call to Turn			
0:30:13	0:27:37	0:02:36	156	ATC Switch to Tower			
0:30:28	0:27:37	0:02:51	171	ATC Clearance to Land			
0:33:08	0:27:37	0:05:31	331			Ok, stall. Go around power.	
0:33:10	0:27:37	0:05:33	333		Power set.		
0:33:14	0:27:37	0:05:37	337			Correcting.	
0:33:15	0:27:37	0:05:38	338			Climbing out. Runway heading.	
0:33:18	0:27:37	0:05:41	341			Call a missed.	
0:33:19	0:27:37	0:05:42	342		Missed.		
0:33:24	0:27:37	0:05:47	347		I have the airplane.		VSS Disconnect
0:33:52	0:33:52	0:00:00	0	Surprise Nagoya			Data Record 14
0:34:33	0:33:52	0:00:41	41			Ok, I've got a trim runaway.	
0:34:36	0:33:52	0:00:44	44		Ok, I have the airplane.	If you'll please help push.	VSS Disconnect

19.5.6 Subject 6

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	Cr
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Shemya			
0:00:26	0:00:26	0:00:00	0				Data Record 5
0:00:58	0:00:26	0:00:32	32			Ok, the airplane is doing some stuff here. I'm going to go ahead and disengage the autopilot.	
0:01:06	0:00:26	0:00:40	40			Try to stabilize it.	
0:01:13	0:00:26	0:00:47	47			It's doing some major oscillations here.	
0:01:16	0:00:26	0:00:50	50			Ok. There we go.	
0:01:20	0:00:26	0:00:54	54		Very good that's the end of the scenario.		
0:01:21	0:00:26	0:00:55	55				VSS Disconnect
0:01:59				Script Birmingham			
0:02:49	0:02:49	0:00:00	0				Data Record 6
0:03:01	0:02:49	0:00:12	12	ATC Call to Turn			
0:03:38	0:02:49	0:00:49	49	ATC Call to Turn			
0:04:56	0:02:49	0:02:07	127			Whoa!	
0:05:01	0:02:49	0:02:12	132			Ok…	
0:05:05	0:02:49	0:02:16	136			Ok. (argh) I'm going to trim it up, get that trim.	
0:05:09	0:02:49	0:02:20	140			Emergency trim please!	
0:05:10	0:02:49	0:02:21	141		Ok, got it.		
0:05:12	0:02:49	0:02:23	143			Thank you.	
0:05:15	0:02:49	0:02:26	146			Ok. What was that?	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	Cr
0:05:20	0:02:49	0:02:31	151		Ok, I have the airplane.		VSS Disconnect
0:06:20				Script Toledo			
0:06:55	0:06:55	0:00:00	0				Data Record 7
0:07:04	0:06:55	0:00:09	9	ATC Contact Departure			
0:07:14	0:06:55	0:00:19	19	ATC Climb			
0:07:41	0:06:55	0:00:46	46	ATC Call to Turn			
0:07:50	0:06:55	0:00:55	55			Watch it! Whoa!	
0:07:52	0:06:55	0:00:57	57			Whoa, Whoa, Whoa! I've got the airplane!	
0:07:53	0:06:55	0:00:58	58		You have the airplane.		
0:08:04	0:06:55	0:01:09	69		Were still fighting it.	Ok, we just stealing here.	
0:08:08	0:06:55	0:01:13	73		Ok, that's the end of that scenario.		
0:08:09	0:06:55	0:01:14	74				VSS Disconnect
0:09:02				Script Detroit			
0:09:27	0:09:27	0:00:00	0				Data Record 8
0:09:48	0:09:27	0:00:21	21	ATC Call to Slow Down			
0:10:22	0:09:27	0:00:55	55	ATC Call to Turn			
0:10:33	0:09:27	0:01:06	66			Ok. (Argh)!	
0:10:37	0:09:27	0:01:10	70		Ok. I have the	Whoa!	VSS

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	Cr
					airplane.		Disconnect
0:11:34				Script Charlotte			
0:12:18	0:12:18	0:00:00	0				Data Record 9
0:12:33	0:12:18	0:00:15	15	ATC Call to Turn			
0:13:09	0:12:18	0:00:51	51	ATC Call to Turn			
0:14:51	0:12:18	0:02:33	153	ATC Switch to Tower			
0:15:08	0:12:18	0:02:50	170	ATC Clearance to Land			
0:17:21	0:12:18	0:05:03	303			That's Terrible. The ILS is having some sort of effect.	
0:17:31	0:12:18	0:05:13	313			Ok, can I have the power?	
0:17:32	0:12:18	0:05:14	314		Ok.		
0:17:36	0:12:18	0:05:18	318			We have a shaker here! I don't know why though we have good speed!	
0:17:39	0:12:18	0:05:21	321			Do we have max power?	
0:17:40	0:12:18	0:05:22	322		Yes.		
0:17:41	0:12:18	0:05:23	323			Ok, then let's have go around thrust.	
0:17:44	0:12:18	0:05:26	326			I don't understand this!	
0:17:46	0:12:18	0:05:28	328		Ok, I have the airplane.		
0:17:49	0:12:18	0:05:31	331				VSS Disconnect
0:18:27				Script Pittsburgh			
0:18:53	0:18:53	0:00:00	0				Data Record 10

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	Cr
0:19:05	0:18:53	0:00:12	12	ATC Call to Turn			
0:19:41	0:18:53	0:00:48	48			Ok, something is wrong here with the rudder! (Argh!)	
0:19:48	0:18:53	0:00:55	55			Yea, the rudder is dead!	
0:19:55	0:18:53	0:01:02	62			Ok, there is no rudder control, using aileron, and I have the outboard engine up to keep us going!	
0:20:02	0:18:53	0:01:09	69			Ok, I have control here.	
0:20:04	0:18:53	0:01:11	71		Ok, very good. I have the airplane.		
0:20:05	0:18:53	0:01:12	72				VSS Disconnect
0:20:49				Script Nagoya			
0:21:19	0:21:19	0:00:00	0				Data Record 11
0:21:33	0:21:19	0:00:14	14	ATC Call to Turn			
0:22:08	0:21:19	0:00:49	49	ATC Call to Turn			
0:22:25	0:21:19	0:01:06	66	ATC Advisory			
0:23:56	0:21:19	0:02:37	157	ATC Switch to Tower			
0:24:12	0:21:19	0:02:53	173	ATC Clearance to Land			
0:26:02	0:21:19	0:04:43	283			Ok, Ok...The blip is going up, give it emergency trim. Autopilot disconnect.	
0:26:07	0:21:19	0:04:48	288		Ok, you have emergency trim.		
0:26:08	0:21:19	0:04:49	289			Thank you very much. Can you help me with it?	
0:26:13	0:21:19	0:04:54	294			I'm pushing on the control with full forward pressure here.	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	Cr
						At least were climbing. Call missed approach.	
0:26:27	0:21:19	0:05:08	308			Ok, trim is working now.	
0:26:29	0:21:19	0:05:10	310		Ok, very good.		
0:26:30	0:21:19	0:05:11	311		I have the airplane.		VSS Disconnect
0:27:12				Script Roselawn			
0:27:46	0:27:46	0:00:00	0				Data Record 12
0:28:22	0:27:46	0:00:36	36	ATC Call for Spacing			
0:29:04	0:27:46	0:01:18	78			Uh Oh!!!!	
0:29:07	0:27:46	0:01:21	81			Ok, I have problems with controls!	
0:29:10	0:27:46	0:01:24	84			Can you help me with the controls?!	
0:29:12	0:27:46	0:01:26	86		Ok.		
0:29:14	0:27:46	0:01:28	88			Ahhh, I can't control.	
0:29:17	0:27:46	0:01:31	91			I don't know what's wrong. It looks like the controls are jammed! I've got good rudders.	
0:29:20	0:27:46	0:01:34	94		Ok.		
0:29:21	0:27:46	0:01:35	95			So if you can help me with the controls again so I…	
0:29:25	0:27:46	0:01:39	99			Ok, the plane is under control. Do you have control? Ok, I have control.	
0:29:30	0:27:46	0:01:44	104			Trims working and we have good speed.	
0:29:33	0:27:46	0:01:47	107		Ok, I have the airplane.		
0:29:34	0:27:46	0:01:48	108				VSS Disconnect
0:29:48				Surprise Birmingham			Data Record 13
0:31:09	0:31:09	0:00:00	0			Yea, I see runway five……………….What the fuck!!!	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	Cr
0:31:14	0:31:09	0:00:05	5			Ok?	
0:31:15	0:31:09	0:00:06	6		What happened?		
0:31:16	0:31:09	0:00:07	7			I don't know what happened but ...were going back down, were going to bank a little bit. Help me with emergency trim if you have any.	
0:31:21	0:31:09	0:00:12	12		Ok, you have emergency trim.		
0:31:24	0:31:09	0:00:15	15			Pardon my French.	
0:31:27	0:31:09	0:00:18	18		All right, I have the airplane.		
0:31:28	0:31:09	0:00:19	19				VSS Disconnect

19.5.7 Subject 7

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Charlotte			
0:00:25	0:00:25	0:00:00	0				Data Record 5
0:00:45	0:00:25	0:00:20	20	ATC Call to Turn			
0:01:20	0:00:25	0:00:55	55	ATC Call to Turn			
0:03:23	0:00:25	0:02:58	178	ATC Switch to Tower			
0:03:39	0:00:25	0:03:14	194	ATC Clearance to Land			
0:05:04	0:00:25	0:04:39	279			Going around!	
0:05:11	0:00:25	0:04:46	286			Positive rate, gear up!	
0:05:12	0:00:25	0:04:47	287		Set power, gear		

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
					coming up.		
0:05:19	0:00:25	0:04:54	294			Stick shaker.	
0:05:25	0:00:25	0:05:00	300		Ok, I have the airplane.		
0:05:26	0:00:25	0:05:01	301				VSS Disconnect
0:07:03				Script Toledo			
0:07:32	0:07:32	0:00:00	0				Data Record 6
0:07:41	0:07:32	0:00:09	9	ATC Contact Departure			
0:07:52	0:07:32	0:00:20	20	ATC Climb			
0:08:18	0:07:32	0:00:46	46	ATC Call to Turn			
0:08:28	0:07:32	0:00:56	56			Watch your bank angle!	
0:08:29	0:07:32	0:00:57	57		You have the airplane?		
0:08:30	0:07:32	0:00:58	58			I have the airplane.	
0:08:39	0:07:32	0:01:07	67			Ok.	
0:08:44	0:07:32	0:01:12	72		Ok, I have the airplane.		
0:08:45	0:07:32	0:01:13	73				VSS Disconnect
0:10:01				Script Nagoya			
0:10:33	0:10:33	0:00:00	0				Data Record 7
0:10:44	0:10:33	0:00:11	11	ATC Call to Turn			
0:11:46	0:10:33	0:01:13	73	ATC Call to Turn			
0:12:06	0:10:33	0:01:33	93	ATC Advisory			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:13:30	0:10:33	0:02:57	177	ATC Switch to Tower			
0:13:50	0:10:33	0:03:17	197	ATC Clearance to Land			
0:15:30	0:10:33	0:04:57	297			Trim runaway!	
0:15:33	0:10:33	0:05:00	300		Ok.	Ok, disconnect.	
0:33:36	0:10:33	0:23:03	1383				VSS Disconnect
0:33:37	0:10:33	0:23:04	1384		I have the airplane.		
0:16:50				Script Shemya			
0:17:18	0:17:18	0:00:00	0				Data Record 8
0:17:57	0:17:18	0:00:39	39			Looks like the autopilot, disconnecting!	
0:17:58	0:17:18	0:00:40	40				VSS Disconnect
0:17:59	0:17:18	0:00:41	41		I have the airplane.		
0:19:19				Script Roselawn			
0:20:03	0:20:03	0:00:00	0				Data Record 10
0:20:36	0:20:03	0:00:33	33	ATC Call for Spacing			
0:21:27	0:20:03	0:01:24	84	ATC Call to Turn			
0:21:56	0:20:03	0:01:53	113			Looks like...	
0:22:08	0:20:03	0:02:05	125			Definite problem here. I don't know if it is icing or.... if the aileron is jammed.	
0:22:15	0:20:03	0:02:12	132			Generally a little bit of a.	
0:22:24	0:20:03	0:02:21	141		All right, very good.		
0:22:25	0:20:03	0:02:22	142		I have the airplane.		VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:29:05				Script Birmingham			
0:29:28	0:29:28	0:00:00	0				Data Record 12
0:29:40	0:29:28	0:00:12	12	ATC Call for Spacing			
0:30:35	0:29:28	0:01:07	67	ATC Call for Spacing			
0:31:46	0:29:28	0:02:18	138			Ahh ... Pretty good gusts, I'm not sure if it was…	
0:31:54	0:29:28	0:02:26	146			Pitch trim. Disconnect.	
0:31:55	0:29:28	0:02:27	147		Ok, I have the airplane.		VSS Disconnect
0:32:52				Script Pittsburgh			
0:33:37	0:33:37	0:00:00	0				Data Record 13
0:33:58	0:33:37	0:00:21	21	ATC Call to Turn			
0:34:49	0:33:37	0:01:12	72			(Argh) ok, help me out on the pushing!	
0:34:50	0:33:37	0:01:13	73		Ok, pushing.		
0:35:01	0:33:37	0:01:24	84		Ok very good, I have the airplane.		VSS Disconnect
0:36:01				Script Detroit			
0:36:25	0:36:25	0:00:00	0				Data Record 14
0:36:50	0:36:25	0:00:25	25	ATC Call to Slow Down			
0:37:50	0:36:25	0:01:25	85				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:37:51	0:36:25	0:01:26	86		Ok, I have the airplane		
0:38:10	0:38:10	0:00:00	0	Surprise Pittsburgh			Data Record 15
0:39:11	0:38:10	0:01:01	61			Guys? (Argh)	
0:39:12	0:38:10	0:01:02	62		Very nice.		
0:39:13	0:38:10	0:01:03	63		Ok, I have the airplane.		VSS Disconnect
						("Bastards") (Laughs)	

19.5.8 Subject 8

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
(H:MM:SS)	(H:MM:SS)	(H:MM:SS)	(seconds)				
0:00:00				Script Nagoya			
0:00:36	0:00:36	0:00:00	0				Data Record 5
0:00:45	0:00:36	0:00:09	9	ATC Call to Turn			
0:01:14	0:00:36	0:00:38	38	ATC Call to Turn			
0:01:36	0:00:36	0:01:00	60	ATC Advisory			
0:02:58	0:00:36	0:02:22	142	ATC Switch to Tower			
0:03:10	0:00:36	0:02:34	154	ATC Clearance to Land			
0:04:52	0:00:36	0:04:16	256			Argh! I've got a pitch up here, trimming down.	
0:04:55	0:00:36	0:04:19	259			Emergency Trim! Trim forward!	

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:04:56	0:00:36	0:04:20	260		Ok, emergency trim selected.		
0:05:02	0:00:36	0:04:26	266		Ok, we're going real high here.		
0:05:03	0:00:36	0:04:27	267			We're breaking off the approach.	
0:05:04	0:00:36	0:04:28	268		Ok, we're breaking off the approach.		
0:05:06	0:00:36	0:04:30	270			What's our altitude above the ground?	
0:05:07	0:00:36	0:04:31	271		All right, we're at 300 ft.		
0:05:16	0:00:36	0:04:40	280		250 ft.		
0:05:18	0:00:36	0:04:42	282			Gear up!	
0:05:19	0:00:36	0:04:43	283		Gear selected up.		
0:05:20	0:00:36	0:04:44	284		Ok, I have control.		VSS Disconnect
0:06:12				Script Detroit			
0:06:48	0:06:48	0:00:00	0				Data Record 6
0:07:34	0:06:48	0:00:46	46	ATC Call to Slow Down			
0:08:06	0:06:48	0:01:18	78			Whoa! We've got a hard roll over!	
0:08:09	0:06:48	0:01:21	81			Now the other way!	
0:08:10	0:06:48	0:01:22	82		Ok I have control.		
0:08:11	0:06:48	0:01:23	83				VSS Disconnect
0:09:34				Script Shemya			
0:10:16	0:10:16	0:00:00	0				Data Record 7
0:10:52	0:10:16	0:00:36	36			The autopilot is doing some funny stuff! Autopilot's coming off!	
0:10:53	0:10:16	0:00:37	37				VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:10:54	0:10:16	0:00:38	38		Ok, I have control.		
0:13:52				Script Toledo			
0:14:43	0:14:43	0:00:00	0				Data Record 9
0:14:51	0:14:43	0:00:08	8	ATC Contact Departure			
0:15:08	0:14:43	0:00:25	25	ATC Climb			
0:15:29	0:14:43	0:00:46	46	ATC Call to Turn			
0:15:39	0:14:43	0:00:56	56			Whoa! You've gone too far over.	
0:15:40	0:14:43	0:00:57	57		You got it?		
0:15:41	0:14:43	0:00:58	58			I've got the airplane.	
0:15:50	0:14:43	0:01:07	67		Ok, I have control.		VSS Disconnect
0:17:21				Script Pittsburgh			
0:17:57	0:17:57	0:00:00	0				Data Record 10
0:18:07	0:17:57	0:00:10	10	ATC Call to Turn			
0:18:45	0:17:57	0:00:48	48			And we have something going on here.	
0:18:48	0:17:57	0:00:51	51			It's rolling over.	
0:19:02	0:17:57	0:01:05	65			I'm not sure what we got here.	
0:19:08	0:17:57	0:01:11	71		Ok, I'm going to go ahead and take it here.		
0:19:10	0:17:57	0:01:13	73				VSS Disconnect
0:20:44				Script Roselawn			

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:21:31	0:21:31	0:00:00	0				Data Record 12
0:22:09	0:21:31	0:00:38	38	ATC Call for Spacing			
0:22:22	0:21:31	0:00:51	51			I'm getting something weird here! I'm not sure what to tell you but. …	
0:22:25	0:21:31	0:00:54	54			I think it's just chop. I think were just in chop.	
0:22:33	0:21:31	0:01:02	62			Yea, I think its just turbulence. We're in IMC, in icing. I think this is just turbulence.	
0:22:40	0:21:31	0:01:09	69			Ok.	
0:22:42	0:21:31	0:01:11	71		All right, so they want us at 180 knots for spacing, and I'll bring the flaps up on your call.		
0:22:49	0:21:31	0:01:18	78		Yeah, we're getting bounced around a little bit.		
0:22:51	0:21:31	0:01:20	80			I think I'm going to leave the flaps were there at. Unless were pressed and we have too.	
0:22:52	0:21:31	0:01:21	81		Well, we have to speed up so…I mean it would probably be a better idea.		
0:22:58	0:21:31	0:01:27	87		Ready? Ok, flaps coming up.		
0:22:59	0:21:31	0:01:28	88			Whoa!	
0:23:04	0:21:31	0:01:33	93			Come over here! (argh)	
0:23:10	0:21:31	0:01:39	99			Use the power to level it.	
0:23:13	0:21:31	0:01:42	102			That's better.	
0:23:23	0:21:31	0:01:52	112			I don't know what that was.	
0:23:25	0:21:31	0:01:54	114		Ok, I'll take it.		
0:23:26	0:21:31	0:01:55	115		I have control.		VSS Disconnect

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
0:24:29				Script Charlotte			
0:25:35	0:25:35	0:00:00	0				Data Record 13
0:25:43	0:25:35	0:00:08	8	ATC Call to Turn			
0:26:15	0:25:35	0:00:40	40	ATC Call to Turn			
0:28:18	0:25:35	0:02:43	163	ATC Switch to Tower			
0:28:35	0:25:35	0:03:00	180	ATC Clearance to Land			
0:30:04	0:25:35	0:04:29	269			Oh, we have a windshear, look at that windshear!	
0:30:06	0:25:35	0:04:31	271			Let's go around.	
0:30:07	0:25:35	0:04:32	272			Max power!	
0:30:08	0:25:35	0:04:33	273		Max power set		
0:30:09	0:25:35	0:04:34	274			Gear up!	
0:30:10	0:25:35	0:04:35	275		Selected up		
0:30:13	0:25:35	0:04:38	278		Max power set		
0:30:16	0:25:35	0:04:41	281		Gear's up.		
0:30:17	0:25:35	0:04:42	282			Flaps up!	
0:30:18	0:25:35	0:04:43	283		Selected up.		
0:30:33	0:25:35	0:04:58	298		Ok, I'm going to go ahead and take it.		
0:30:34	0:25:35	0:04:59	299				VSS Disconnect
0:30:36	0:25:35	0:05:01	301		Ok, I have control.		
0:31:23				Script Birmingham			
0:32:10	0:32:10	0:00:00	0				Data

Time	Data on Time	Elapsed Time	Elapsed Time	FTE	SP	EP	C
							Record 14
0:32:22	0:32:10	0:00:12	12	ATC Call to Turn			
0:32:59	0:32:10	0:00:49	49	ATC Call to Turn			
0:34:21	0:32:10	0:02:11	131			Whoa! Hard Roll!	
0:34:31	0:32:10	0:02:21	141			And. Let's trim it up.	
0:34:33	0:32:10	0:02:23	143			I need some help holding it down!	
0:34:34	0:32:10	0:02:24	144		Ok, I'm holding, I'm holding, I'm holding.		
0:34:36	0:32:10	0:02:26	146		I have control.		VSS Disconnect

20. APPENDIX M - COMMENTS MADE BY EVALUATION PILOTS ON THE POST-FLIGHT QUESTIONNAIRE

Group	Comments
No Aero/No Upset	I was surprised by the difficulty I had in recovering from an upset. I feel that I could do much better with some recovery training. The Charlotte microburst scenario was the easiest for me to recover from. I think this was due to the fact that I have had windshear training. I ranked simulator training as being most effective because you can get much more done in a given length of time, it is safer, and simulators are so good these days. Thanks for the great experience.
No Aero/No Upset	This is a very valuable experience. The brief and flight times are just right, in order to have a neutral outlook and experience.
No Aero/No Upset	The scenarios simulated in this study should at minimum be discussed in airline training. I have been a pilot for two airlines thus far in my career and I believe airplane upset training is deficient in the airlines. One of the airlines that I have worked for only provided stall recovery training. The other airline provided stall and windshear/microburst training and very limited icing recovery training (the icing recovery training was not formally covered but is printed in the manuals). I believe that experiencing these scenarios first-hand was a very valuable and eye opening experience.
No Aero/No Upset	
No Aero/No Upset	With the aerobatic training that I know of it involves looking at references outside the aircraft. I'm not sure if that would help at all since these examples happened in IFR.
No Aero/No Upset	Veridian gathered data from me, and I gathered much useful data also. The actual in-flight recreation of these scenarios was eye opening. The debrief afterwards was particularly invaluable. My airline's upset recovery training is sorely lacking. Industry wide, the standards are probably too low for recovery training. Never have I been trained to use differential thrust to recover from loss of control around the yaw axis. I think the minimum training for upset should be about 4 hrs ground and 2 one-hour sim sessions. These should include present scenarios (as used in the experiment) as well as unpredictable "surprises."
No Aero/No Upset	
No Aero/No Upset	Great program, I think a pilot in some of these cases who was familiar with the plane and the environment would have a better chance of recovering a couple of these due to familiarity with the aircraft and its failure modes
No Aero/Upset	Excellent Program. Provides insight to decision making relating to loss of control situations.
No Aero/Upset	Excellent experience. Never flown with a tape before. Very quick to use alternate controls
No Aero/Upset	Very informational. Would like to go through scenarios again knowing the correct control inputs to see the difference.
No Aero/Upset	This was a real eye opener. I think the biggest surprise for me was the speed of which things get out of hand, i.e., Toledo, Shemya. Identification of the problem was difficult for me. Having not seen the upsets in the past, I hadn't thought about the logical recovery. I didn't have the necessary time. I didn't use the captain for much. Crew coordination was terrible. Sitting in the classroom this stuff seems like a piece of cake. This was really a humbling experience. I don't feel ground school by itself is sufficient. Clear that a training program is long overdue. (Ground simulation only)
No Aero/Upset	Outstanding program on upset recovery. I have never experienced these upsets (thankfully) in real life and my reaction to some of the upsets was

Group	Comments
	different then what I thought I would have reacted beforehand. The actual feel and response, the seat-of-the-pants feelings one gets in the Lear is a 100% improvement over-ground based simulators. Thank you for everything!!!
No Aero/Upset	This was a very valuable experience. I'd like to see regulation pass to mandate in-flight upset training combined with simulator and ground school.
No Aero/Upset	
No Aero/Upset	Airline training ins designed to "fill squares"" "Cast" (Critical aircraft situation training) Training is rushed to satisfy FAA requirements. I am left feeling unprepared for such emergencies. It was fun, very worthwhile. The in-flight simulator trips off like a gs but goes farther. Handling like a 737 but I never flew a 737. The old airplanes don't have sensitivity in VVI and attitude. Specifically handling qualities just to teach people to keep out of the dirt. Aerobatics are negative training. Having in-flight sim gives people more realistic training in initial FO and captain's in in-flight sim and refresh yearly in ground in three flight to be enough for replications add instruction as necessary.
Aero/No Upset	Upset training would be extremely valuable to any pilot flying high performance equipment, and should be required. At the very least training in the sim should be used, with aircraft training being highly recommended.
Aero/No Upset	Most difficult problem was admitting/realizing the problem. As in MD-80, "Trim"(aural warning) would make these realizations much easier. Rolling to 90 degrees, as technique is hard to commit to without training; same with use of differential power (rudder). Unloading the wings and taking altitude loss is not natural either.
Aero/No Upset	Trim button was awkward to use.
Aero/No Upset	Value of basic aerodynamics - Simple flight operations w/ Raw Data. Hands on flying so that dependence on the autopilot doesn't lead to complacency. Pilots are being trained to follow procedures to such an extent that perhaps common sense and basic aerodynamic understanding is disregarded in the attempt to seek a checklist. Also in "worse case" scenarios, pilots are expected to hand fly while they rarely hand fly in normal ops. Often simple review of unfortunate accidents through ground teaching would help, e.g., the split throttles to control roll, and it's so obvious but did not come to mind! This time was a great experience & positive learning opportunity. In-flight more realistic then simulator because of sinking feeling from turns.
Aero/No Upset	Very beneficial evaluation. Now that I have been briefed on the correct techniques I would like to see how I would perform several months from now, when the information is not fresh in my mind. It was also great to have training that was not focused on just windshear. As not all of the CFIT involved windshear activity. I strongly feel a wider range of upset training most be included in airline training.
Aero/No Upset	This is probably the most educational single day I've ever spent during my aviation career. I definitely leave humbled but also enlightened. Thank you. It really makes me want to research each of these accidents more.
Aero/No Upset	These flight profiles should be put into some sort of in flight pilot training for all new hire pilots to allow them to think "out of the box." Rote memory training does not apply to all flight profiles
Aero/No Upset	The airline that I fly for has unusual altitude recovery training but nothing as eye opening as this. Excellent
Aero/Upset	Actual in-flight training, I think is very important with these scenarios. I believe a pilot with aerobatic experience would be more valuable as well.

Group	Comments
	The Roselawn accident happens so fast, the only way to prevent it is to have the situational experience and avoid placing the aircraft in the scenario. I got experience overall.
Aero/Upset	An excellent training aid. Slight improvements in the display could be made. In addition, I recommend a change to the aircraft model on the Shemya accident scenario recreation, the aircraft felt quite stable. I look forward toward returning, this was quite a great experience. Thank you for the chance to fly your Learjet in such an exciting way! I hope your data collection goes well.
Aero/Upset	
Aero/Upset	
Aero/Upset	More emphasis on the fam flight on handing. I feel more in the way of unusual altitude training for the airlines should be mandatory. Beyond what is currently given. These scenarios are excellent & should be used partially if not entirely in all sim training.
Aero/Upset	At least the sim instructors should have full in-flight upset training to help explain the "real world" recovery procedure to their students
Aero/Upset	I found the in-flight training to be excellent. I experienced flight situations that I was never exposed to before, and learning conventional recovery techniques are not always the best, and sometimes the worst thing to do. My aerobatics background did not help me as much as I thought it would.
Aero/Upset	I found the experience very educational and informative. The study was conducted very professionally and well planned. The aircraft however, flew differently then the types I have experienced. The handling (stall) characteristic and recovery techniques needed were unlike what I have experienced in the past but, still applicable. In some cases the airline training I have received for some recoveries could be considered counter-productive. In some of the accidents simulated the aircraft (in the real accident) was turned inverted early on. The ability to simulate this would be valuable (that is to have a fully aerobatic test aircraft). In all, the study and the experience were extremely valuable and I felt fortunate to have been apart of it.
In-flight	Upset training needs to be incorporated into airline training. This had been a great value to me.
In-flight	The recreation/simulation of real-life accidents and incidents adds the chilling intensity to the exercise of this type of training/checking. evaluation that will effect real and worthwhile changes in our industry in the form of improved safety (i.e., reducing fatalities and hull loss). My training/learning time effort and energy has never been better spent than it was in this program. Schedule with safety.
In-flight	I really enjoyed the training and feel that it has made me a much safer and better-paced pilot. Anytime you need some pilots feel free to call me back. I really appreciated Russ's [the instructor] emphasis on unloading and breaking the stall. I'd like to see that included in more airline training.
In-flight	
In-flight	Training would be much less meaningful without the ability to feel the 'g' forces. I would never know how hard I could pull on a recovery without feeling it on my body. It turns out much more performance was available to me than I ever would have known. If anything, this training has shown me more of what I did not know then I ever suspected! A real eye opener. Thanks for the opportunity.
In-flight	This is the best training I have ever had since I started flying.
In-flight	The program I was at Veridian was by far the most beneficial training concerning upset and unexpected aircraft malfunctions that I have had to

Group	Comments
	date. I have been flying for nine years and feel the training I received at Veridian by far will prepare me for upsets and the like better, then any other previous experience. I believe the "real life scenarios" and "line type" training/testing events as to the whole training experience. One of my greatest complaints concerning training to data has been the "vacuum type" or controlled environment training. During conventional training you have no real surprises. I was shocked how real and hard hitting this training was. I was shocked how fast it happens when you're not prepared for the event or upset. I shall forever remember how unlucky all those previous pilots were and how ill prepared they were to have dealt with their demises. I only wish training was available to all my fellow pilots at my current airline, so I could feel more comfortable sitting in the back as a passenger. I give this newly developed program the highest regards. Thanks Veridian.
In-flight	Very good program, invaluable experience-all of the Veridian folks are awesome! Definitely gives you a lot to think about. Two incidents on icing were really good. The whole experience is very enlightening since there are very few cues to see the problem. Will always remember the high altitude lag time in your mind as w/any sim.

21. APPENDIX N – COMMENTS MADE BY EVALUATION PILOTS IN THE POST-FLIGHT DEBRIEF[200]

21.1 BIRMINGHAM

Group	Comments
No Aero/No Upset	
	Was surprised.
	Did the roll but not pitch up.
	Feel yoke and trim.
	Took care of roll, twin disconnect.
	Was a good call.
	Used full aileron as prescribed, held trim down, could have rolled, fly airplane with trim.
No Aero/Upset	Did correct recovery to start to correct initial roll.
	Did a good job on this one, immediately on the trim.
	Called for emergency trim, used bank to roll to bring nose down// just starting to roll
	Controlled the roll then nose pitched up and pulled power back, thought about rolling.
	Tripped on AOA as called for emergency trim.
Aero/No Upset	
	Pulled power back.
	Recover from roll upset, did call for emergency trim.
	"I'm climbing deliberately" Need to roll it again.
	Was not using the trim.
	Didn't use trim or roll.
	Hit altitude restriction. Did not roll or pitch up.
Aero/Upset	Tripped on AOA same as previous, could have used trim same as previous.
	Just started to put bank it.
	Got in mode of bank secondary.
	PIO in roll, called for emergency trim.
In-flight	Correctly put in roll, said "trim runaway" emergency trip called, did not roll off on pitch up.
	Big roll recovered. Called for emergency trim and recovered the aircraft.
	Was rolling left but a little left, Tripped off but would have recovered, did all the right things.
	Good roll off, tripped on AOA called for emergency trim. "No clacker."
	"Need to dump it."

[200] Blank cells indicate that a subject did not comment on that scenario during the debrief.

	Banked the airplane-excellent. "I learned bank yesterday with Russ."
	Looked like very fast trim runaway." Pretty good vertical gust." Put in bank until tripped.
	Handled roll okay. SP took it because really slow. "The nose is going up" Did not remember use of bank.

21.2 TOLEDO

Group	Comments
No Aero/No Upset	
	Tripped off on pitch up.
	No data.
	Tripped off.
	Disconnected autopilot very quickly.
	Call was right on, " watch your pitch" did not say, "I've got it" loud enough.
	Grabbed it and recovered it.
	Did not work.
No Aero/Upset	Took over very soon.
	Took it at 120%, called bank angle.
	Real good job. No hesitation, really good recovery. Announced problem.
	Did a real good job. At 60 degrees took over, called "my airplane" Did all steps in procedure.
	Difficult to reach, disconnect autopilot.
Aero/No Upset	Grabbed it fairly soon, added power.
	"Excessive bank c," didn't vocally say had it.
	Took it early.
	Didn't say, "I've got it."
	Still trying to get what was going on.
	Took it fairly early, did not early enough.
	Took over right away, recovered no problem, called "altitude immediately.
Aero/Upset	
	Went pretty well, wasn't pulling.
	We hit the ground "you got it" "no."
	Handled this one really nice. Got on it really quick, called over bank, should have said got it.
	Quickly took the airplane, cautioned captain on altitude, airspeed, and bank very nice recovery.
	"I'm helping." Once got on the airplane. Did recover the airplane, was very good.
In-flight	Minimum of two challenges before take aircraft. Have three rule-if two missed approaches then divert.
	Recovered but took over late.
	Probably should have taken over sooner, got really fast, pull whatever airplane can do. Called attitude rolled and used rudder.
	Took over right away, real good job, really good, hand signal to increase altitude (flight).
	Cautioned the captain. A little hesitant to take the airplane-used rudder

Group	Comments
	well and enough g. Did not crosscheck the ADI.
	Didn't vocalize, started late ~90 degrees, but able to recover so pulled & called bank angle.
	Took over a little bit late, not until asked if he had it. Didn't pull enough.

21.3 SHEMYA

Group	Comments
No Aero/No Upset	
	Undo the last thing.
	That was fantastic, everything was perfect, really get a lot more of this gs don't get control feel.
	Pitch over.
	Did really well first one.
	"Here's you root beer" First one to do this right caught the roll and disconnected. Cue autopilot, flew correctly w/trimmer, "cheers."
	Input then disconnect.
	Did not work. Rudder Problem.
No Aero/Upset	Took autopilot off after input.
	Grab then disconnect.
	Did not take autopilot off before making control input.
	Pushed then disconnected autopilot. Did announce the problem first.
Aero/No Upset	Took off autopilot.
	Fighting autopilot, didn't disconnect.
	Did a really good job, took autopilot off first.
	Artificial input-fault of scenarios.
	Had pressure when tripped off.
	Over control in pitch, pushed then took autopilot.
Aero/Upset	
	Too large an input.
	Opposed it, disengaged it.
	Disconnected automation quickly.
In-flight	Commented on roll. Disconnected autopilot then input. Very nice. Was flying with fingertips. Did not announce the problem.
	Input before took autopilot off. Over controlled on the initial input.
	Did not trip autopilot first.
	737 easy to fly at altitude.
	Got rid of autopilot immediately, adopted gentle flying technique.
	Rolled then disengaged autopilot. Right away figured this out-flew with fingertips.

Group	Comments
	Input then clicked off autopilot. Did announce the problem, "That was a really good one."

21.4 NAGOYA

Group	Comments
No Aero/No Upset	Took over
	Pulled up and stalled, no emergency trim. Trim thought later about banking.
	Thought of banking later.
	"Very good," Called for emergency trim, good call. Good catch.
	Called for emergency trim and recovered.
	Did not try.
No Aero/Upset	One of the few to recover this, called for emergency trim immediately.
	Emergency trim, nonevent, recovered.
	Realized didn't add power-in fact moved power to idle. Did not call for emergency trim. When asked-"I could have rolled it." Did not disconnect the autopilot.
	"I didn't expect this" Slowly went over the top. Used emergency trim-very good recovery. "Hadn't thought about rolling. Had learned that in a lecture but forgot." Little slow on master disconnect-thought of it in time.
	Called for emergency trim, straight tail icing techniques is different.
Aero/No Upset	Pulled power back, no emergency trim.
	Did not disconnect the autopilot.
	"Just beautiful," rolled out.
	"I got all I can do."
	Did not hit master, a little slow.
Aero/Upset	
	Could have stood it up on a wing.
	Called for circuit bred, did not call for emergency trim.
	Could have called for max power and emergency trim.
	Called for emergency trim very quick.
	Didn't roll the airplane.
In-flight	Noticed right away, did not call for emergency trim. Did mot remove autopilot since was hand flying, should have increased power, counterintuitive to recover to twining flight.
	Real nice, nice out into the crosswind, called for emergency trim, rolled in, held it in bank, and trimmed during roll, best recovery of this one.
	"Unusual to think in 3D."
	Asked what was the spacing. Full forward yoke. Called trim emergency.
	Did not recover, got on wheel master correctly. Would have pushed

Group	Comments
	power more, should have rolled the airplane. "Oh @#$#" remembered too late.
	Asked for emergency trim right away-a nonevent, good job, was thinking of banking to return to ILS.

21.5 CHARLOTTE

Group	Comments
No Aero/No Upset	
	Didn't first recognize shaker sense no volume, "very good."
	Not Done. Broken cable in wheel/column ended flight---G forces are a big part of these accidents. Would be nice to have more compass showing, fastest localizer.
	Called it correctly, could have called "windshears"' remained same configuration until position out of it.
No Aero/Upset	Did well.
	Recover, "flying at edge of shaker."
	Went real well. Flew out of it real nice. Flew the shaker.
	Went real well and did everything right; very standardized training across airplane and airlines.
Aero/No Upset	Flew to the shaker.
	Pretty good job, changed configuration.
	Did most things right, did change configuration, asked about airspeed.
	Hit green button for trim.
	Weren't consistent in the shaker showed leave configuration same.
	Pretty good, did change configuration but should not have.
	Went all right, did recover "set thrust, flaps 8", didn't change configuration.
Aero/Upset	
	Did everything right.
	Techniques were good, should have called out windshear.
	Maneuver done quite well, need to have nose 10 degrees not twenty degrees, configuration change.
	Did fine, Procedure was excellent, said missed rather than windshear, RJ annunciates windshear.
In-flight	Suspected windshear briefing. Called missed and go around. Did not state windshear. Very nice recovery. Did call for positive rate call. Flying in and out of the shaker.
	Really nice job.
	Tripped on initial pitch up, didn't go long enough for good data.

Group	Comments
	Announce, set max power, go to shaker.
	Upset by ILS performance. Did not announce windshear." Walked the airplane on the shaker.
	Every thing right except vocalize.
	Did real well. Brought gear and flaps up " realized I shouldn't have done this."

21.6 PITTSBURGH

Group	Comments
No Aero/No Upset	
	Called windshear during turn.
	Did pull back the power, split power.
	Did not use split thrust.
	Never thought about split thrust, did not realize rudder disconnected on second time.
	Grabbed the wrong throttle.
	Did not work. Differential power.
No Aero/Upset	Tried differential power but not enough.
	Recovered w/split thrust.
	Just rolled over. Did not have full aileron and did not split power. "Would not have thought about split power in any of these."
	Tripped on delta DT rudder and aileron was used, needed to split the power.
Aero/No Upset	Powered up then pulled back. Now thought about differential power.
	Did not use power.
	Did not use secondary controls.
	Didn't even think of using power.
	Recovered.
	First time lost it.
Aero/Upset	
	Should have reduced thrust on leg.
	"This is bad" didn't use split thrust.
	I could have used differential thrust.
	Looked good initially.
	Communication was good, started to recover and called for differential thrust, very good.
In-flight	Asked in turbulent around here. Called out handover rudder. Put in full rudder and aileron then nothing-no differential thrust.
	Perfect, called for split thrust and recovered immediately.
	Stuffed in rudder, best recovery to date, differential thrust.
	"Differential power"- never would have thought of this without the training

Group	Comments
	I had yesterday."
	10 points for this--"Rudder is dead" "Push up the power on the left engine" Recovered. Very good recovery.
	Got on the controls quickly and used differential trust, may want to be more emphatic on power.
	Twister recovery to split power and control input. Real nice job.

21.7 ROSELAWN

Group	Comments
No Aero/No Upset	
	Caught it about 30.
	Recovered but tripped, didn't configure.
	Could feel the nibble.
	Called for flaps back down, needed to use rudder & aileron to down AOA.
	Wheel column cover broke.
	Called for power, nose not down enough.
No Aero/Upset	Still in upset but nearing cloud deck.
	Recovered, use speed to pull out gently, still had plenty of altitude, did not return configuration.
	Tripped off very quickly. Put in a very aggressive input.
	"I got an asymmetry" SP took over. "Felt exactly like aileron asymmetry in Brasilia simulator." Did not put flaps back.
Aero/No Upset	Called for flaps down-first one.
	Clear knew needed altitude, increased speed.
	Full aileron and rudder, didn't return configuration. Flaps back down.
	Didn't work right pulled from hem.
	Did really well.
	"Pretty sporty" should have reduced pulling, didn't return configuration.
Aero/Upset	
	Lost altitude.
	Powered out-perfect.
	Classic response.
	Did same as accident, didn't lower nose enough, power was right, couldn't distinguish over control and ice.
	Recovered but too slow to stop final snatch, did not pull back very good, did call for flap back down.
In-flight	Checked icing protection. Tripped of early. Diagnosis was misleading.
	Flew out of this immediately, put flaps down.
	Happened fast-recovered 4000 feet, nice gentle pull up. "Knew this was the accident w/flaps coming up," could have set flaps back.
	Had couple of cycles. "Unloading would have been the thing to do."

Group	Comments
	Stated, "jammed control." Firewalled the throttle-so this saved the airplane-needed to reduce the angle of attack-used split thrust-good. Did not have excessive bank angles. Did recover from it. "737A have secondary stall."
	Hesitate to get in to this because was very gentle in response. Gently pushed, power maybe should have been added, was willing to lose altitude, and could have put flaps down, good recovery.
	Did not want to change configuration (flaps). Differential throttle and rudder was holding right aileron.

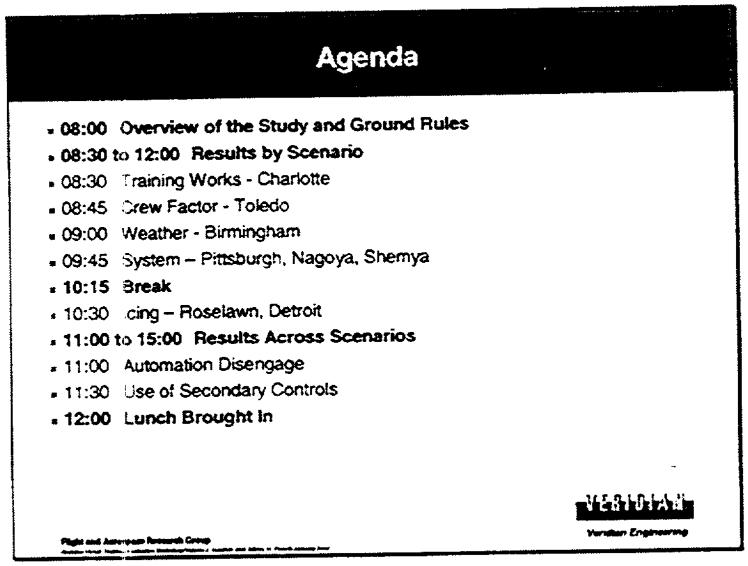
21.8 DETROIT

Group	Comments
No Aero/No Upset	No data since speed up.
	Powered right out of it.
	Needed to push.
	Need to reduce AOA, gradually up, good call on flaps-undo what you did.
	Called to drop flaps, pulled back and made it worse, did have it for a short time, would be interesting to have tail stall encounter.
	Initial input was correct.
No Aero/Upset	Immediately added power and flew right out of it, "150 won't work."
	Added differential power and went inverted, "should have angle of attack."
	Didn't change the power initially. The pulling increased the angle of attack and made it worse.
	Banked from side to side until tripped-did not identify as ice. Tried to rudder walk to get time to figure out. Very high roll rate.
Aero/No Upset	Tripped on rudder input.
	Did good, had an excursion.
	Correctly called for flaps. Real gentle pull up, could have added power.
	Worked out really well.
	Called for max thrust, powered out.
	Recovered this one, "Watch your altitude" response " I don't care about my altitude figured out not to pull back hard.
Aero/Upset	
	"Power for 180 knots."
	Did really well, didn't push enough, commented that wouldn't worry @ altitude.
	Waddle.
	"Aileron jam" instead of "uncommanded roll," recovered by pushing the nose down. May be negative training-never to stall only to shaker, power out of it, and gain altitude. Only thing did not do was power up.

Group	Comments
In-flight	Wing rock almost went inverted.
	Called for leading edge, in for a long time, used power to get out of this, did recover.
	Called ATC "Couldn't hold altitude."
	"So ingrained to maintain altitude" "roll only problem, so never thought of pitch.
	Powered up right away and had full control in. Verbalized real well.
	"Any airline training negative reinforcement for icing-its shaker training" Didn't break it enough with power to recover, rudder wasn't causing problem AOA was.
	Very correctly wanted to put down flaps. Split power after aileron made it worse. Wanted to stop the roll rate.

22. APPENDIX O – SLIDES AND COMMENTS FROM AIRPLANE UPSET RECOVERY TRAINING RESULTS WORKSHOP

Slide 1



ALPA commitment to project. – John Cox
Introductions

Slide 2

Agenda (afternoon)

- 13:00 Understanding and Controlling Flight Path
- 13:30 Expanded Stall Recovery Training
- 14:00 Applying Large versus Subtle Control Inputs
- 14:30 Provide Both Knowledge and Practice
- **15:00 Break**
- **15:15 to 15:45 Recommendations**
- **15:45 to 16:00 Executive Summary**
- **16:00 to 17:00 Where Do We Go From Here?**
- **17:00 Wrap Up**

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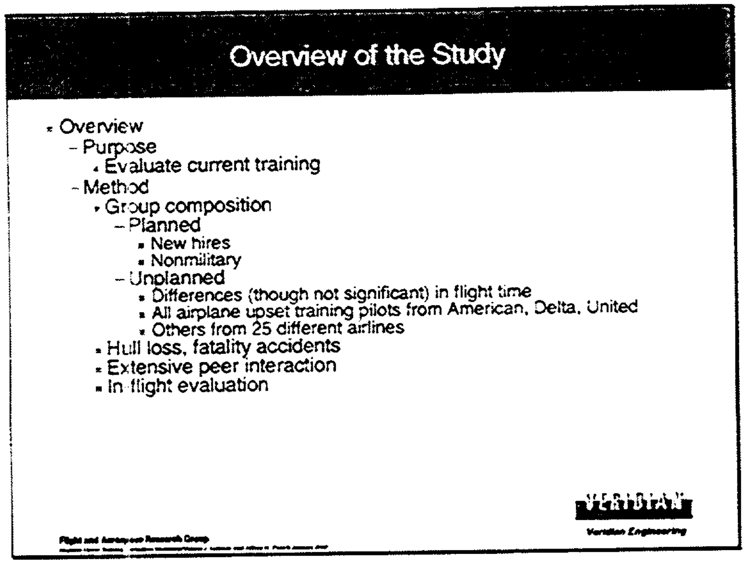
Slide 3



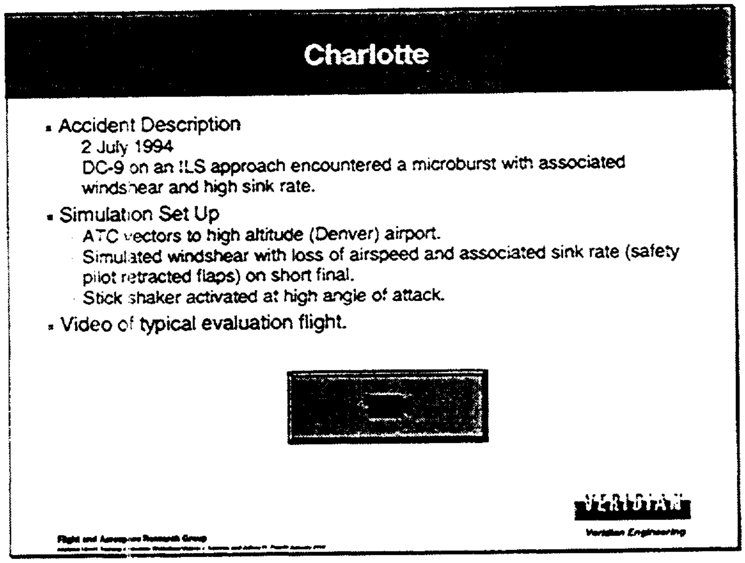
There is no standard application of "Advanced maneuvers" training across the air carrier industry. Participation by the airlines is totally voluntary. There are no standards for maneuvers to be taught, depth of training, pilot certification levels (i.e., private/commercial/ATP/CFI), and no check standards.

Slide 4

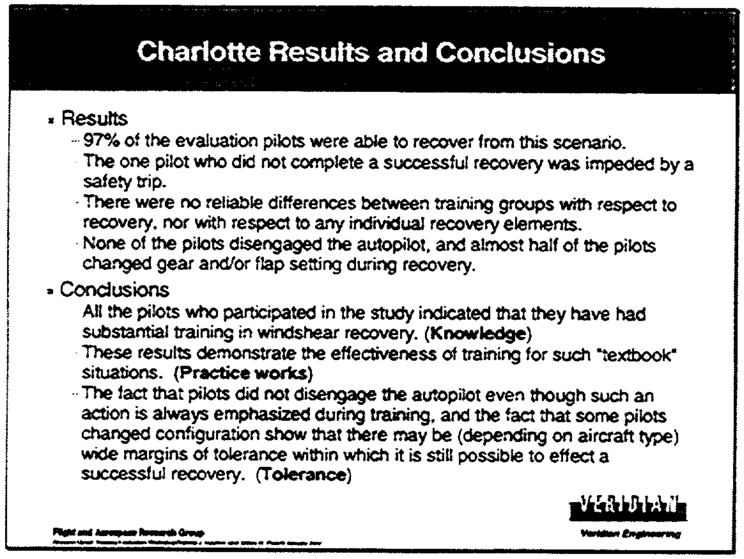
Workshop Ground Rules

- We can't change the past – please don't ask us to.
- All statements should be data driven.
- Assumed that everyone read the executive summary and report.
- No filibusters.
- Keep on schedule.
- Workshop notes will be used in the report.

Slide 5


Charlotte
Accident Description
2 July 1994
DC-9 on an ILS approach encountered a microburst with associated windshear and high sink rate.
Simulation Set Up
ATC vectors to high altitude (Denver) airport.
Simulated windshear with loss of airspeed and associated sink rate (safety pilot retracted flaps) on short final.
Stick shaker activated at high angle of attack.
Video of typical evaluation flight.

Slide 6



State of awareness of autopilot. If the pilot was hand flying the aircraft then not disconnecting may not be cause for failing a particular action.
Airbus does not call out disconnecting the autopilot.
Success on this scenario suggests that repeated simulator training works.

Slide 7

Toledo

- Accident description
  - 15 February 1992
  - The captain flying a DC-8 on a second missed approach became spatially disoriented and allowed the airplane to enter a nose low steep bank.
  - The first officer took control but was not able to recover.
- Simulation set up
  - VSS automatically flew the ATC directed missed approach including the over bank.
  - Evaluation pilots controls became active above 70 degrees of bank.

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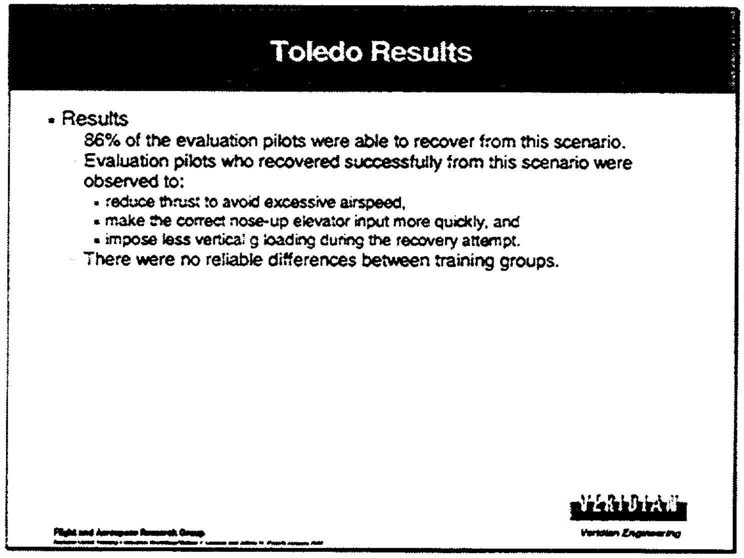
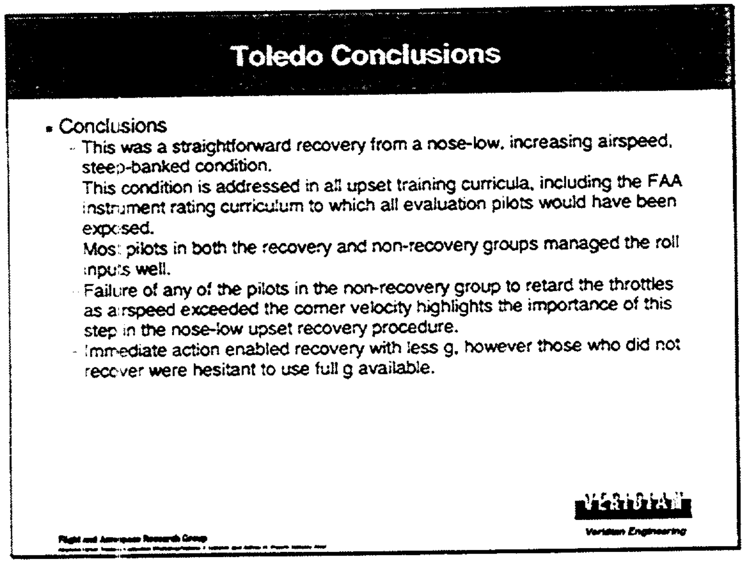
Slide 8



G- Rare to use full g capability. Important to educate.
Corner speed – hard to know what speed is in different configurations (should educate pilots how corner speed changes and what affects corner speed).
Make clear definition on corner speed vs. crossover speed.
There was no g-meter so pilots didn't know what g level they were at.
Should there be a g-meter in the cockpit?
How to train pilots to use full capability of aircraft?
Mention that the altitude loss was because of evaluation pilot delay in response.
G-need to be concerned how to teach and also what pilots really do.
Need to keep speed under control so as not to have to pull hard.
Technology may be able to help present best performance envelope.

Slide 9



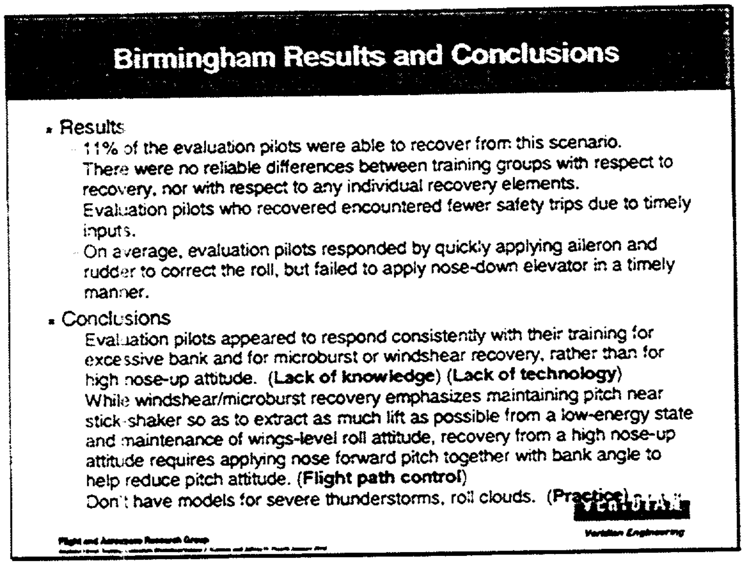
Define corner speed.

Slide 10

Birmingham

- Accident description
  - A Beech C99 on final approach encountered a thunderstorm cell with strong vertical air shafts and associated turbulence and entered a nose high attitude with 45 degree left bank.
- Simulation set up
  - ATC vectored ILS in moderate turbulence, "thunderstorms in the vicinity".
  - ~400 foot AGL large roll excursion followed by pitch up.
  - Roll excursion was controllable with ailerons alone.
  - Pitch excursion was only controllable with emergency trim and/or bank angle.

Slide 11



Endorse use of bank angle in nose high recovery.

Use of thrust could be disastrous but is airplane dependent – thrust should be secondary response.

Is there a way to teach both primary and secondary controls during this time of stress?

Hard to get consensus between operators and manufacturers. Use the manufacturers recommendations.

Pilots revert to what they have seen before. Maybe not taught in initial flight training or not sufficiently – need better initial training.

Perhaps oversimplified – pilots need to take into consideration the actual flight conditions.

Test pilots may not be in the same situation as the real upset pilot and using secondary controls should not be in the first string of responses. How to train differently for different engine/aircraft configurations?

Does pilot really need to know what is going on (the knowledge issue) or just to fly the airplane and use all of the controls at his/her disposal.

Need to clarify that lack of roll did not mean lack of pitch down input.

Ground simulators don't realistically provide turbulence.

Some visual displays get out of alignment.

Slide 12

Pittsburgh

- Accident description
  - 9/8/94
  - During initial approach a B737 experienced uncommanded yaw/roll, due to movement of the rudder to its blowdown limit, apparently in the opposite direction commanded by the pilots.
- Simulation set up
  - ATC vectored approach, "following traffic ahead".
  - Simulated rudder hardover (yaw + roll).
  - Ineffective roll control (with ailerons alone) below crossover speed.
  - Effects of split throttle consistent with under-wing engine aircraft.
- Video of typical evaluation flight.

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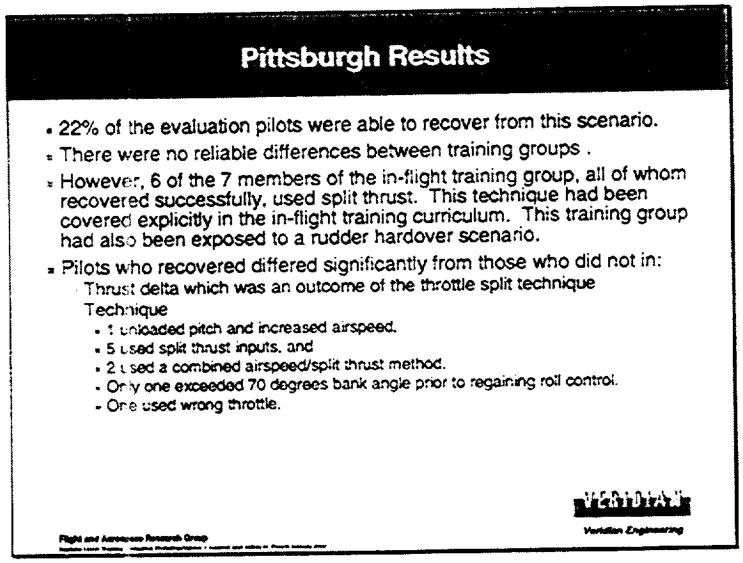
Slide 13



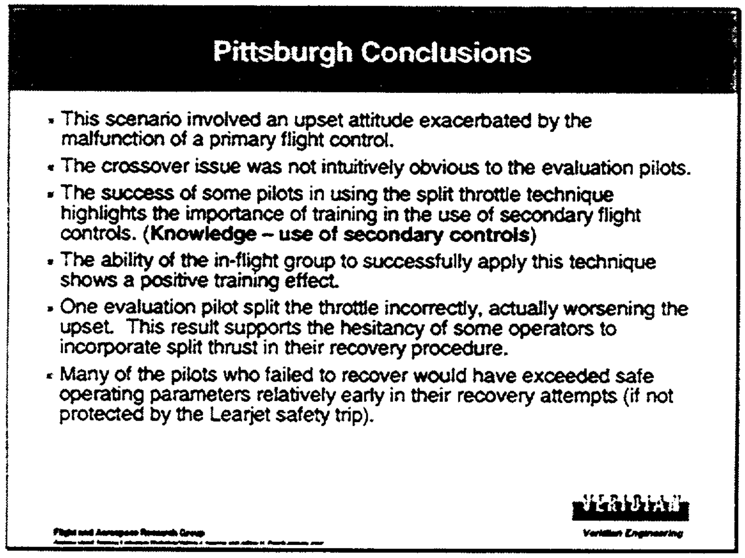
Need to get into pilots head that this is an AOA issue. Pilot is thinking about speed not AOA and doesn't want to release. Emphasize that lower AOA provides more roll axis control. Talk about crossover AOA and not only speed.

Flight path awareness – energy awareness training should be increased.

A lot of conditions where the aircraft doesn't respond is AOA dependent and should be emphasized in training.

Needs to be industry standard for the term "unloading the aircraft"

Slide 14



Define crossover speed
Define crossover alpha
Define unload.

Slide 15

Nagoya

- Accident descriptions
  - 26 April 1994
  - The pilot manually flying an Airbus 300 on approach inadvertently triggered the GO lever, which changed the flight director to Go Around mode and caused a thrust increase.
  - The autopilots were subsequently engaged, while the pilot continued pushing against the control wheel.
  - The horizontal stabilizer automatically trimmed to the full nose-up position and the aircraft stalled.
- Simulation set up
  - ATC vectors to ILS final.
  - Simulated autopilot pitch up with runaway pitch trim below 400 feet AGL.
  - Recoverable only with emergency trim and/or bank angle for flight path control.

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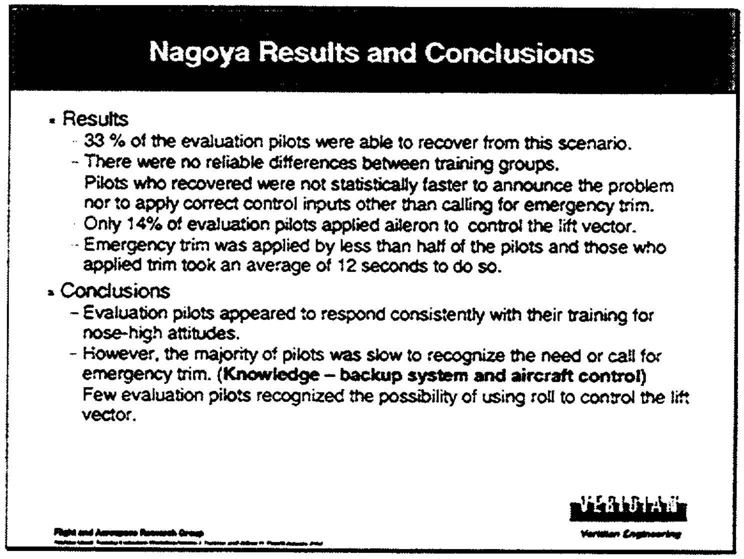
Slide 16



Shows lack of training to use roll to control nose high attitude.
Need to clarify what new hires have had coming in to the study (doesn't reflect more experienced airline pilots).
These data again strongly support the need for training pilots to roll the lift vector off in a nose high recovery.

Slide 17

Shemya

- Accident descriptions
  - 4/6/93
  - Leading edge wing slats of an MD-11 inadvertently deployed in cruise flight, leading to reduced pitch stability combined with light control forces resulting in violent, pilot-induced, pitch oscillations.
- Simulation set ups
  - High altitude cruise conditions, autopilot engaged.
  - Small roll upset followed by pitch up.
  - Changed (simulated) $M\alpha$ to reduce longitudinal stability.
  - Increased control gain to increase pitch sensitivity.

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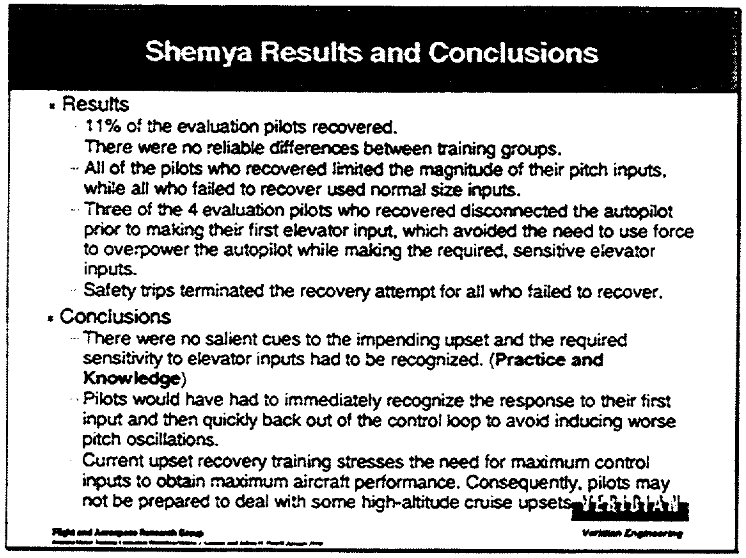
Slide 18



Do all airlines teach hand flying the aircraft at altitude? Simulators don't accurately reflect high altitude flight characteristics.
A/A used to encourage crews to experience hand flying at altitude.
Airbus says that their new generation simulators are much better.

Slide 19

Roselawn

- Accident description
  - 31 October 1994
  - During descent in icing conditions an ATR 72 experienced uncommanded roll after retracting flaps and rapid descent due to sudden aileron hinge movement reversal caused by a ridge of ice accreted behind the de-ice boots.
- Simulation set up
  - ATC vector and assigned speed above flap speed.
  - Briefed "icing conditions".
  - After retracting flaps, reduced stall margin.
  - Small increase of alpha during turns caused one wing to stall and aileron to snatch.
- Video of typical evaluation flight.

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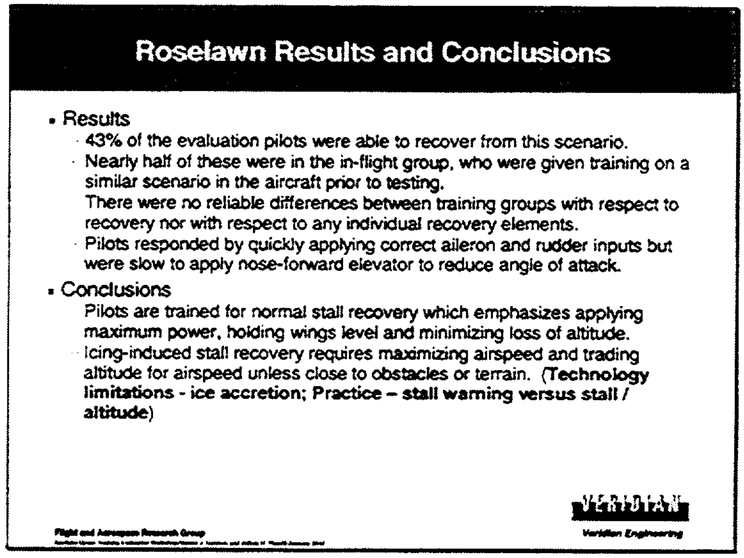
Slide 20



Need to train for full stall recovery as opposed to approach to stall.
Real problem with high altitude stall – it takes altitude loss to recover.
Simulation fidelity issues – need to train behavior modification.
Pilots associate pitch attitude to AOA – need to learn the differences.
Need to focus on altitude loss in approach to stall vs. stall. The further away from the ground the more altitude they have to play with. Energy management knowledge.
Sim packages today have reasonable pitch data beyond the stall without beta or roll input.
NASA is working to expand aero packages for simulators.
Training aid was for large jet transports that are not grossly affected by ice.
Need a method of cueing the crew as to the aircraft energy state.
Make it clear in the report that pilots are trained for "approach to stall" recovery.
How long do the basic skills for a private (full stall) last.
Full stall training has to be done in the simulator.

Slide 21

Detroit

- Accident description
  - 9 January 1997
  - EMB-120RT experienced uncommanded roll and rapid descent caused by a thin, rough accretion of ice on the lifting surfaces.
- Simulation set up
  - ATC vector.
  - Briefed "known icing".
  - ATC requested speed reduction during turn.
  - Increase of alpha during turn caused asymmetric stall.

Slide 22

Detroit Results and Conclusions

- Results
  - 44% of the evaluation pilots were able to recover from this scenario.
  - There were no reliable differences between training groups.
  - Pilots who recovered reached a higher airspeed than those who did not.
  - Pilots who recovered took more time on each of the measures (e.g., time to announce problem, time to first correct control input).
- Conclusions
  - The pattern of results in this scenario is very similar to that of the Roselawn scenario, the only other icing event in the study.
  - Comparisons underscore the importance of sacrificing altitude for airspeed and the criticality of airspeed and angle of attack for sufficient control effectiveness when surfaces are contaminated with ice.
  - Participating pilots in both maneuvers commented on the inadequacy of ice accretion warning (**Technology limitations - ice accretion**) and standard stall-recovery training (**Practice – stall warning versus stall / altitude**).

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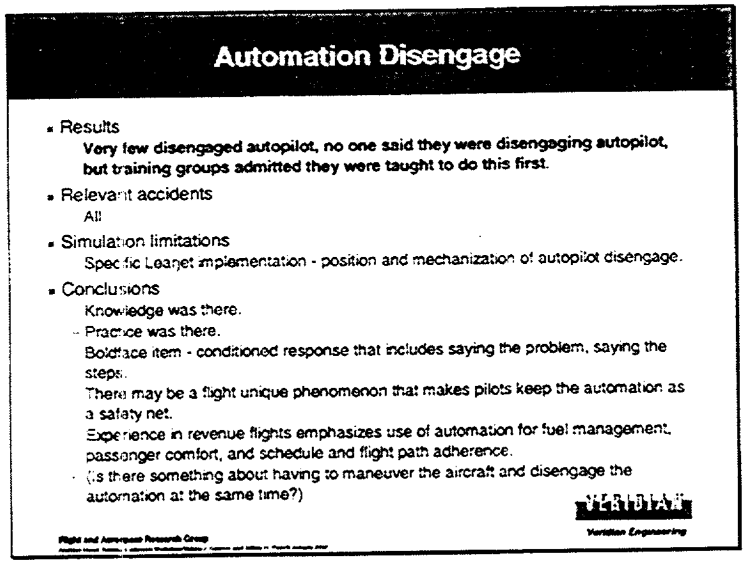
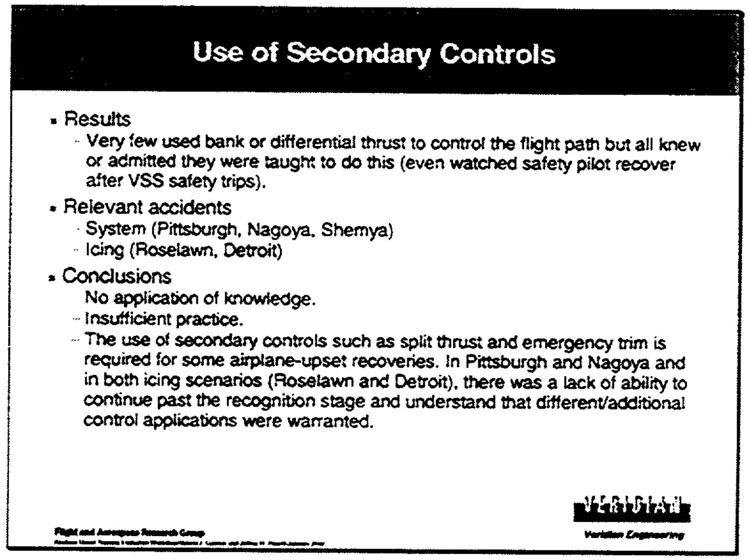
Slide 23



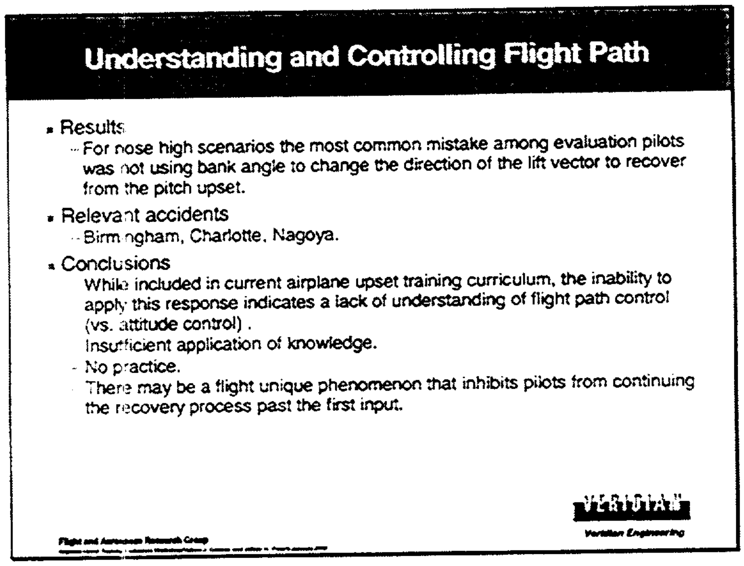
Disengage the autopilot may need to be revised to "go to the lowest level of automation". May be aircraft type specific.
Need to design automation that fails passively.
Disconnecting the auto pilot should be while holding the yoke firmly not just pressing the disconnect button.
Study highlights the need for training to disconnect the autopilot whenever the airplane is departing the intended flight path.
Recover with primary flight controls then trim off pressures with secondary flight controls.

Slide 24



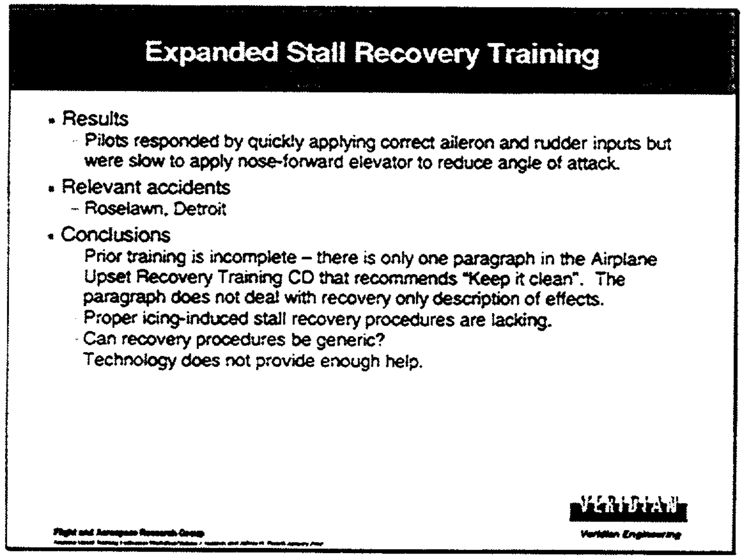
Group differences were extensive – maybe can't get a standard
All but impossible to regulate a certain level of training.
Need to look at military training equivalent to ATP and see what differences are.
Could develop recognized (FAA) training program that could be used by the airlines for selection process.
Is the use of bank a secondary control? Probably not.
Were the evaluation pilots exposed to sufficient training to say that they "knew about the use of secondary controls".
"Thrust control". Differential thrust is just a subset of secondary controls. Also "trim" should be a secondary control.

Slide 25



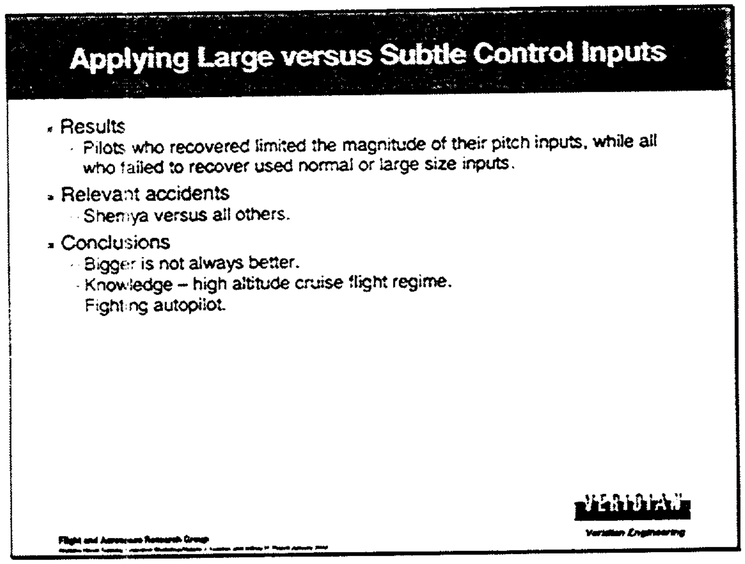
Need to identify what general aviation training brings to the airlines now and how to affect this learning.
Need to modify the behavior to reflect the types of aircraft they are getting into.
Not true that all airlines train to use roll to recover from nose high – those in the group, yes.
ATP is really an instrument rating – not a level of competence.
The advanced training may suffer from being last in line in the training because the standards come first in the sim training.
Need regulatory requirements and performance standards from the FAA to take burden off airlines and corporate to do what they each feel is right. Can the training that is done now be modified to train for other aircraft other than general aviation.
Establish an industry expectation (not FAA mandated) that certain training be received before being accepted into the airlines.
Amount of time for training is short and airlines must compress.
Difference between training and effective training – need to verify that training is indeed effective.

Slide 26



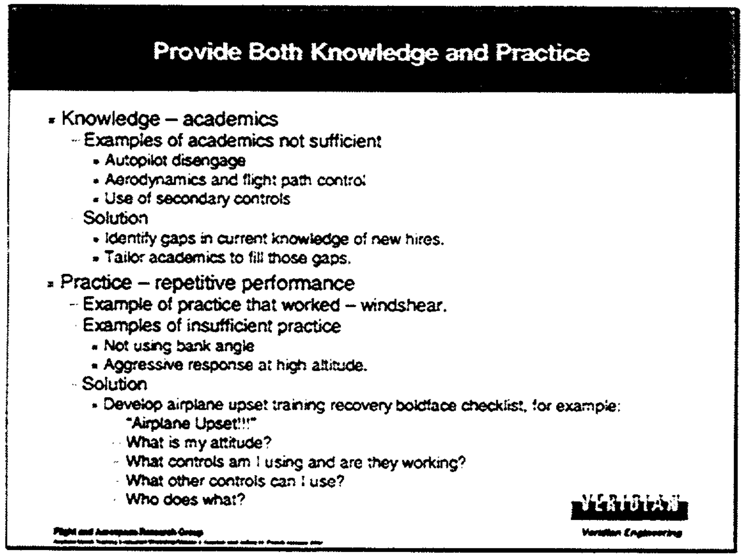
Don't use the word "incomplete" and training was not available for specific aircraft type.
The only problem for the big guys is performance degradation.
Should not train to cause but to aircraft control in general.
Can't call it a procedure – just an awareness. Shouldn't emphasize the procedure part of it.
Do airline pilots need to have a "procedure" to grasp onto?
Maybe use "forward stick" first in any case where ground impact is not imminent.
When talking about stall and upsets need to regain control first – so "unload".
What about tailplane stall? Three stalls; traditional, wing, tailplane.
Need to rely on regulatory agencies to protect aircraft in the design phase?
Find generic technique such as "primary controls (roll, rudder. unload).
Transition training should require expanded training (stalls, upsets, etc).
Need to convince regulatory agencies that stall recovery depends on not losing altitude (maybe require that it be done at idle power).
Could technology display flight guidance that would recover the aircraft? NASA wants to do this kind of research.

Slide 27



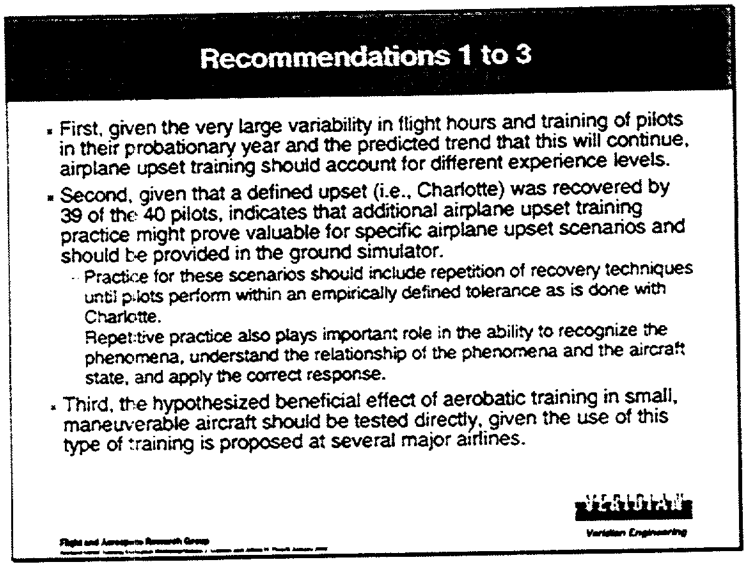
Still comes down to "what are the basics that you want to be taught" Need to train high altitude maneuvers; how to disconnect the autopilot, especially at high altitude/high speed, and should this be a procedure only when the autopilot is disconnected when the aircraft is doing something the pilot doesn't want it to do.

Slide 28



"Attitude, attitude" and then decide whether it is nose high or nose low.
Need to admit that something is wrong.
CRM techniques should be incorporated into recovery.
Definition of terms to communicate during the crisis.
The study showed that these are problems but was not designed to, nor does it provide a resolution..
Does being proficient at upsets make a better all around pilot? (economics)

Slide 29

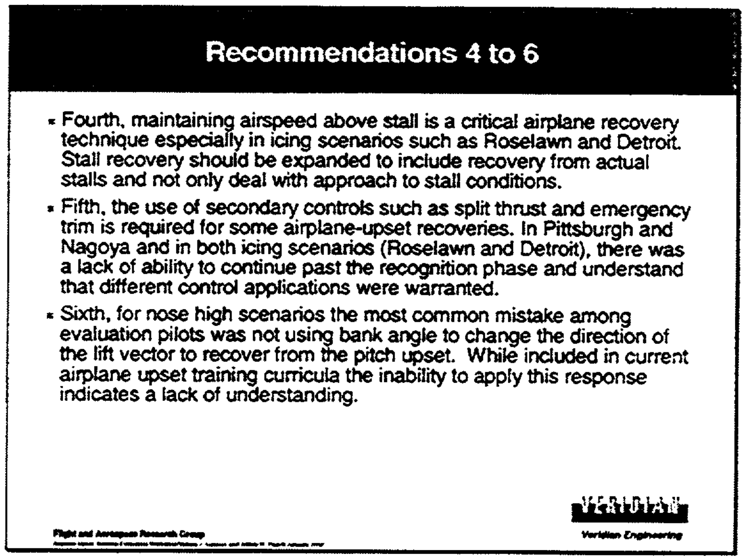


The benefit of aerobatic training may be obtained only using a low performance, side-by-side configured aircraft that can perform vertical maneuvers.

Training must consider where in a pilot's career aerobatic training would be most useful.

There is currently a lack of aircraft instrument recovery training.

Slide 30



The fourth recommendation should read "maintaining angle of attack below stall is a critical airplane recovery technique …"
The fifth recommendation should read: "the use of secondary controls such as thrust control and trim is required to aid in some airplane-upset recoveries".
Recommendation six should end with "the inability to apply this response indicates the need for repetitive practice".
Define unloading the aircraft.
An angle of attack display is needed.

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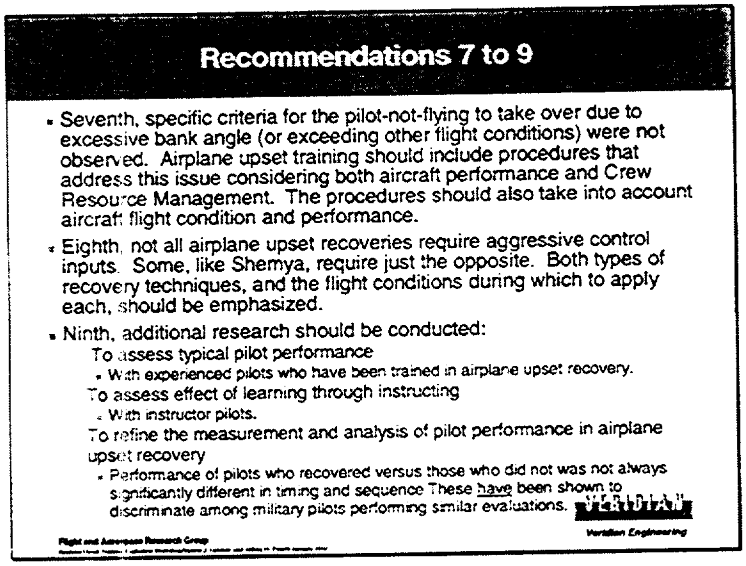


Training manuals should have criteria for taking over from an incapacitated pilot.

At high altitude, aircraft should be hand flown changing the attitude indicator one degree at a time.

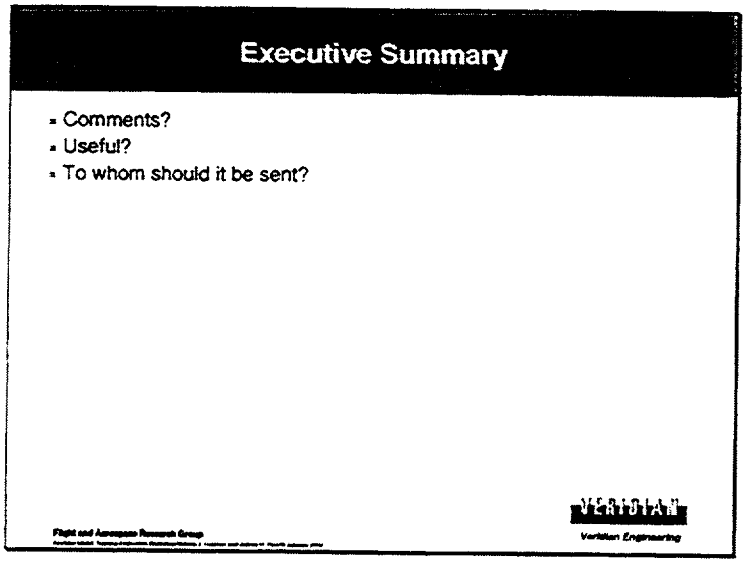
High altitude airplane upset recovery must be trained.

Delete "like Schema" in recommendation eight.

Change "typical" to "line" pilot in recommendation nine.

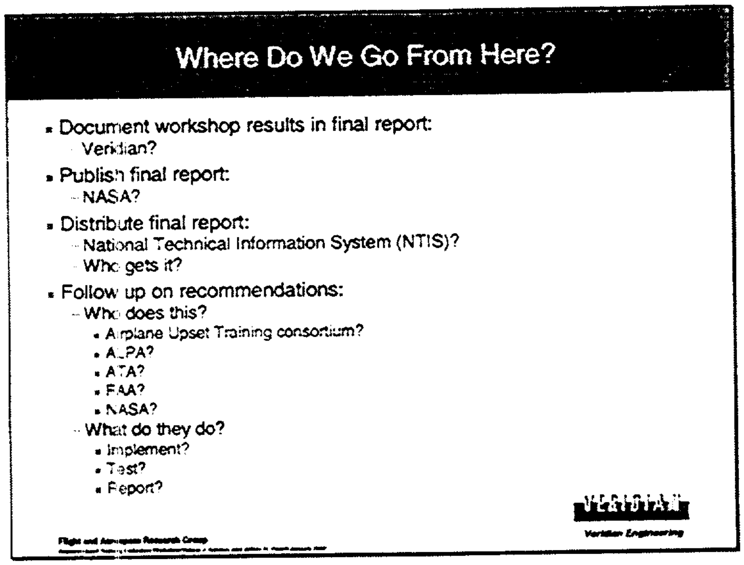
Add amplitude measures and more extensive safety pilot's evaluation to recommendation nine.

Slide 32



The results should be provided in chronological order to match the report.
Delete the recovery procedures since too much detail.
The summary was useful and should be distributed with the report.

Slide 33



Veridian agreed to include a written description of the workshop and the discussion that occurred, send that description to the attendees, change the description in response to comments, and incorporate the resultant description into the final report.
NASA will publish the final report. It will be distributed through NTIS with no restrictions so everyone may have a copy.
The Airplane Upset Training consortium is no longer active so ALPA will use its training arm to take the results to its members starting with the steering/oversight meeting. The results will be briefed at the ALPA training council meeting in February 2002. ALPA will also use its members on the Society of Automotive Engineers G-10 committee to use the results to develop realistic training.
The FAA agreed to review the mandated stall training requirements for possible incorporation of airplane upset training – at least to actual stall conditions. There were comments that FAA needs to mandate advanced maneuvers training for air carriers. Only then will the industry see requirements standards that can be universally implemented and refined.
NASA will continue with piloted simulations to test ground simulator post stall recovery fidelity.

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24. ACRONYMS AND ABBREVIATIONS

$\overline{X}$	Mean
1^{st}	First
A9	Aileron Tag Code
AA	Maximum Angle of Attack Safety Trip Tag Code
AAMP	Advanced Aircraft Maneuvering Program
AB	Aileron Differential Pressure Safety Trip Tag Code
AD	Aileron Surface Rate Safety Trip Tag Code
ADI	Attitude Direction Indicator
AF	Aileron Feel Acceleration Safety Trip Tag Code
AFM	Air Force Manual
AGL	Above Ground Level
AK	Alaska
AL	Alabama
alp_dot_I	Angle of Attack Rate (Inertial)
ALPA	Air Line Pilots Association
alpha	angle of attack
alpha_cf	angle of attack (complimentary filtered)
alpha_cfa	angle of attack (complimentary filtered, analog-to-digital)
alpha_I	angle of attack (inertial)
alpha_vc	angle of attack (vane corrected)
alphadotia	angle of attack rate (inertial, analog-to-digital)
anova	Analysis of Variance
AOA	Angle of Attack
AP	Autopilot
ap_disc	autopilot disconnect
ap_eng	autopilot engaged
AQP	Advanced Qualification Program
AR	Arkansas
ATA	Air Transport Association
ATC	Air Traffic Control
ATP	Air Transport Pilot
AZ	Arizona
B	beta
BA	Trim Negative Limits Safety Trip Tag Code
BB	Top Rolling Moment Safety Trip Tag Code
BD	Elevator Differential Pressure Safety Trip Tag Code
beta_cf	angle of sideslip (complimentary filtered)
beta_cfa	angle of sideslip (complimentary filtered, analog-to-digital)
beta_vc	angle of sideslip (vane corrected)
betadot_I	angle of sideslip rate (complimentary filtered, inertial)
betadotia	angle of sideslip rate (inertial, analog-to-digital)
BF	B Limit Safety Trip Tag Code
BUF	Buffalo
C	Centigrade

C2	Yaw Damper or Autopilot Engaged Safety Trip Tag Code
CAA	Civil Aviation Authority
CAP	Captain
CAST	Critical Aircraft Situational Training
CCS	Configuration Control System
CD	Compact Disc
CE	Configuration Control System
CF	Attitude Gyro Flag Safety Trip Tag Code
CFIT	Controlled Flight Into Terrain
cg	center of gravity
CI	Low Hydraulic Fluid or Standby Fly By Wire Disengage
CO	Colorado
D9	Rudder Tag Code
da	aileron position
das	lateral stick position
dasm	lateral stick position (model)
DB	Rudder Differential Pressure Safety Trip Tag Code
DD	Rudder Surface Rate Safety Trip Tag Code
de	elevator position
deg	degree
deg/sec	degrees per second
degk	degrees Kelvin
des	Longitudinal Stick Position
desm	Longitudinal Stick Position (model)
destrimc	Longitudinal Trim Command
df	Degrees of Freedom
DF	Rudder Feel Acceleration Safety Trip Tag Code
DGAC	Direction Generale de l'Aviation Civile
display02	Displayed Indicated Airspeed
display11	Displayed Altitude
display14	Displayed Radar Altitude
dr	Rudder Position
drp	Rudder Pedal Position
drpm	Rudder Pedal Position (model)
ds	Horizontal Stabilizer Position
E9	Elevator Safety Trip Tag Code
EA	Normal Acceleration Safety Trip Tag Code
EB	Elevator Differential Pressure Safety Trip Tag Code
ED	Elevator Surface Rate Safety Trip Tag Code
EF	Elevator Feel Acceleration Safety Trip Tag Code
EFIS	Electronic Flight Instrument System
EMT®	Emergency Maneuver Training
EP	Evaluation Pilot
EPR	Engine Pressure Ratio
EST	Event Start Time
event_m	Event Marker

F/A	Fighter/Attack
F/O	First Officer
FAA	Federal Aviation Administration
FAR	Federal Air Regulation
fas	Lateral Stick Force
FBW	Fly By Wire
FD	Flight Director
fes	Longitudinal Stick Force
FF	Manual Safety Trip Tag Code
FL	Florida
fps	feet per second
frp	Rudder Pedal Force
FSF	Flight Safety Foundation
Ft	foot
FTE	Flight test Engineer
Ft/min	feet per minute
fuel_fuse	fuel in fuselage in pounds
fuel_total	total fuel in pounds
G	Gravity
GA	Georgia
Gamma	Flight Path Angle
GPWS	Ground Proximity Warning System
GS	Ground Speed Safety Trip Tag Code
h_cf	Altitude MSL (Complimentary Filtered)
h_dot_cf	Rate of Climb (Complimentary Filtered)
h_radar	Radar Altitude
Hdg	Heading
hdot	Rate of Climb
hdot_dot_I	Rate of Climb Rate (Inertial)
hp	Pressure Altitude
hp_ana	Pressure Altitude (Analog)
HRIRB	Human Research Institutional Review Board
IA	Iowa
IAC	Information Access Company
IAG	Niagara Falls Airport Identifier
IATA	International Air Transport Association
IC	Initial Condition
ID	Identification
IFS	In-flight Simulation
IL	Illinois
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IN	Indiana
INS	Inertial Navigation System
Ixx	Moment of Inertia about Longitudinal (X-) Axis
Ixz	Product of Inertia about Longitudinal/Vertical (X/Z) Axes

Iyy	Moment of Inertia about Lateral (Y-) Axis
Izz	Moment of Inertia about Vertical (Z-) Axis
JAA	Joint Aviation Authorities
KIAS	Knots Indicated Airspeed
LA	Louisiana
LBA	Luftfahrt-Bundesamt
lbs	pounds
LOFT	Line-Oriented Flight Training
mach	Mach Number
manova	Multivariate Analysis of Variance
max	Maximum
MDA	Minimum Descent Altitude
MFI	Multifunction Indicator
MI	Michigan
Min	Minimum
Model_stall_alpha	Model angle of attack at stall
MS	Mean Square
ms	milliseconds
MSECONDS	milliseconds
MSL	Mean Sea Level
N_1	Engine Speed
NASA	National Aeronautics and Space Administration
nm	nautical mile
NM	New Mexico
nond	Non-Dimensional
NTIS	National Technical Information Service
NTSB	National Transportation Safety Board
nx	Longitudinal Acceleration
ny	Lateral Acceleration
NY	New York
Nz	Vertical Acceleration at Aircraft Center of Gravity
Nzp	Vertical Acceleration at Pilot's Station
OH	Ohio
p	Roll Rate
p_mrd	roll rate (model, rotated, delayed)
PA	Pennsylvania
PA-CR	Power Approach - Cruise
pf	Pilot Flying
Ph.D.	Doctorate of Philosophy
phi	Bank Angle
PIO	Pilot Induced Oscillation
PNF	Pilot Not Flying
ps	Static Pressure
psf	pounds per square foot
psi	Aircraft Heading
PTS	Practical Training Standards

q	pitch rate
q_md	pitch rate (model, delayed)
qbar	Dynamic Pressure
qci	Impact Pressure (indicated)
r	yaw rate
r_mrd	yaw rate (model, rotated, delayed)
radalt	Radar Altitude
rec_cf_alpha	Recorded Angle of Attack (Complimentary Filtered)
rec_psi_cf	Recorded Aircraft Heading (Complimentary Filtered)
RFT	Recurrent Flight Training
rms	root mean square
ROC	Rochester Airport Identifier
RT	Reaction Time
SAT	Standard Acceptance Tests
SD	Standard Deviation
Sec	Second
SLD	Super-cooled Large Droplets
SP	Safety Pilot
SS	Sum of Squares
ST	Safety trip
stab_trim	Horizontal Stabilizer Trim
sys_eng	VSS system engaged
TAT	Total Air Temperature
temp	temperature
theta	Pitch Attitude
thrust_l	Thrust (Left Engine)
thrust_r	Thrust (Right Engine)
THS	Target Handoff System
TRM	Trim
TX	Texas
U.S.	United States
UAR	Unusual Attitude Recovery
v_cf	True Airspeed (Complimentary Filtered)
v_dot_I	Airspeed Rate (Inertial)
v_gust	Wind Gust Speed
V_A	Maneuver (corner) speed
Va	Vertical acceleration
V_{F20}	Flaps 20° or less speed
V_{F40}	Flaps more than 20° speed
Vfe	Flap Extend Speed
VFR	Visual Flight Rule
Vi	Indicated Airspeed
vi_ana	Indicated Airspeed (Analog-to-Digital)
VIP	Variable Information Processing
V_{LE}	Extended speed
V_{LO}	Transition speed

V_{NE}	Never Exceed Speed
V_{REF}	Reference speed
VSS	Variable Stability System
Vstall	Stall Airspeed
vt	True Airspeed
V_{XOVER}	Crossover speed
WI	Wisconsin

25. GLOSSARY

Advanced Qualification Program – "The AQP sets proficiency objectives and requires training and evaluation to be conducted in a crew environment. It is a closed loop training concept requiring a lot of input, especially from airline training departments, as carefully prepared individual profiles are built up and recorded on each pilot" (Smallwood, 2000, p. 236).

Corner speed – "Corner velocity /also called corner speed ... is the minimum speed at which an aircraft can pull its maximum rated Gs. An aircraft at corner velocity attains maximum instantaneous turn performance... At speeds above the corner speed, turn performance drops off. Corner speed also affects the minimum turn radius. The size of the turn radius of an aircraft depends on the speed it is traveling. A faster aircraft requires a larger circle to turn in than a slower one. However, the turn radius isn't only a function of speed. It also depends on the number of Gs a pilot pulls during the turn. An aircraft at a constant speed will make a relatively wide circle at 1 G but will turn in a very tight circle at 7 or 8 Gs. The corner velocity is the speed that gives the optimum balance between turn rate and turn radius"[201]

Part 61 was updated 10 October 2000 and applies to:

The requirements for issuing pilot, flight instructor, and ground instructor certificates, ratings, and authorizations; the conditions under which those certificates, ratings, and authorizations are necessary; and the privileges and limitations of those certificates, ratings, and authorizations.

Part 121 applies to domestic, flag, and supplemental operations.

1. Domestic and flag operations are scheduled operations with:
    a. Turbojet-powered airplanes, or
    b. Any airplane having more than 9 passenger seats or a payload capacity of more than 7500 pounds.
2. Supplemental operations are non-scheduled operations or all-cargo operations with:
    a. Airplanes having more than 30 passenger seats or a payload capacity of more than 7500 pounds, or
    b. Any propeller-powered airplane having more than 9 and less than 31 passenger seats, that is also used in domestic or flag operations, or
    c. Any turbojet-powered airplane having a passenger seat configuration of 1 or more and less than 31 seats, excluding each crewmember seat, that is also used in domestic or flag operations.

Part 135 applies to:

1. Commuter or on-demand operations
    a. Commuter operations are any scheduled operation conducted with at least five round trips per week on at least one route. Commuter operations may be conducted in any

[201] http://www.voodoo.cz/falcon/agf.html

airplane, other than turbojet powered airplanes, having 9 passenger seats or less and a payload capacity of 7,500 pounds or less.

2. The transportation of mail by aircraft conducted under a postal service contract.
3. Nonstop sightseeing flights for compensation or hire that begin and end at the same airport, and are conducted within a 25 statute mile radius of that airport.

Stall – "An airplane is stalled when the angle of attack is beyond the stalling angle. A stall is characterized by any of, or a combination, of the following:

a. Buffeting which could be heavy at times,
b. A lack of pitch authority,
c. A lack of roll control,
d. Inability to arrest descent rate."[202]

Total Qualification Program – "is based on individual pilot proficiency, applied to a single aircraft type, operated by a specific airline" (Smallwood, 2000, p. 287).

Unload - "reducing the angle of attack" (Airplane Upset Recovery Training Aid, 12 May 1998, p. 2.38).

[202] Airplane Upset Recovery Training Aid, 12 May 1998, p. ix.

26. DISTRIBUTION OF REPORT

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13. ABSTRACT *(Maximum 200 words)*

Airplane upset accidents are a leading factor in hull losses and fatalities. This study compared five types of airplane-upset training. Each group was composed of eight, non-military pilots flying in their probationary year for airlines operating in the United States. The first group, "No aero/no upset," was made up of pilots without any airplane upset training or aerobatic flight experience; the second group, "Aero/no upset," of pilots without any airplane-upset training but with aerobatic experience; the third group, "No aero/upset," of pilots who had received airplane-upset training in both ground school and in the simulator; the fourth group, "Aero/upset," received the same training as Group Three but in addition had aerobatic flight experience; and the fifth group, "In-flight" received in-flight airplane upset training using an instrumented in-flight simulator. Recovery performance indicated that clearly training works—specifically, all 40 pilots recovered from the windshear upset. However few pilots were trained or understood the use of bank to change the direction of the lift vector to recover from nose high upsets. Further, very few thought of, or used differential thrust to recover from rudder or aileron induced roll upsets. In addition, recovery from icing-induced stalls was inadequate.

14. SUBJECT TERMS
Aerobatics training, Airline pilot training, Airplane upset accidents, In-flight simulation

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